ERIC Document Resume	See Instruction Sheet	DATE OF RESUME	DATE RECEIVED

A. PUBLICATION DATA

1. ERIC NUMBER	2. ORIGINATOR CONTROL NO(S).	3. IDENTIFICATION NO.
ED001316	NA	NA

DO NOT WRITE IN SPACE BELOW

4. AUTHOR(S):
Kansas City Public Schools

5. TITLE OF DOCUMENT ABSTRACTED:
Curriculum Guides in: Physics: General
Advanced Placement
(College Level)

6. PUBLICATION TITLE:
Secondary Curriculum Bulletin No. 113

7. EDITOR(S):
NA

8. PLACE OF ORIGIN
ORG. Kansas City Public Schools
ST. Kansas City,
CITY, STATE Missouri
TELE. EXT.
INST/LOC CODE

9. PUBLISHER OR SOURCE
Kansas City Public Schools
Kansas City, Missouri

10. VOL.	11. PAGES	12. MO./YR.	13. TOTAL PP.
NA	NA	Jul 61	68

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TYPE OF REPORT
PROPOSAL ☐
IN-PROGRESS ☐
FINAL ☒
FOLLOW-UP ☐

OTHER ERIC REFERENCES:

ERIC SATELLITE CODE

B. INDEXING DATA

14. SUBJECT AREA

15. TYPE OF ENDEAVOR
curriculum guide

16. INDEXING TERMS (6-12)

advanced placement	student evaluation			
Physics	students, gifted			
curriculum	secondary schools			

17. ABSTRACT (MAX. 250 WORDS)

The general physics curriculum is planned for those whose general ability is better than average and is offered in grades eleven or twelve. General objectives are; to develop critical thinking through the scientific method; to understand basic physical laws and man's place in the universe; and to develop a scientific ability and interest. Eleven units of study are outlined with experiments and related activities. Sample tests are included. Some of the areas covered are: molecular physics, force and motion, heat, light, electricity, and mechanics.

The Advanced Placement Physics course is a college level course taught in high schools for a selected group of highly able students. Units are outlined in mechanics, heat, wave motion, electricity and magnetism, optics, and atomic physics. A sample test requiring a full understanding of the concepts taught is included to aid the teacher in student evaluation. Texts, references, audio-visual aids and professional aids are listed in the guide.

ERIC No.

18. SOURCE OF ABSTRACT

C. FUNDING DATA

19. SUPPORTING ORGANIZATION	20. DIVISION OR DEPT.	21. CONTRACT NO. / PROJECT NO.
	22. TOTAL COST OF PROJECT	
	23. DURATION OF PROJECT	U.S. Department of Health, Education, and Welfare Office of Education

ED001316

TD 2

CURRICULUM GUIDES

in

PHYSICS: General

✓Advanced Placement
(College Level)

Secondary Curriculum

Bulletin No. 113

Kansas City, Missouri

Public Schools

July, 1961

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U. S. DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
OFFICE OF EDUCATION

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INTRODUCTION

With the rapid advance in research and discovery, and with the wide application of the principles of physics to our economy and armed services, a need has arisen for highly trained citizens in this fundamental science. We cannot afford to lose time.

There is, however, nothing revolutionary about what is being developed to answer the need for physicists: a high school course of fifty years ago was on an academic level close to the first college course of today. This fact is no reflection on present-day teachers. It was the result, rather, of the "natural" selectivity involved in the limited number of persons who went to high school in the early 1900's. If students were not "academically talented," they were not interested in a high school education. Today, then, with a highly selected group chosen from the vastly increased enrollment of our high schools, we can certainly perform the same type of college-level work.

That is half of the picture. The other half shows the need for informed persons who will not necessarily specialize in science. We need highly trained <u>citizens</u> wether they become physicists or not.

Therefore, two physics curricula have been developed: GENERAL PHYSICS and ADVANCED PLACEMENT PHYSICS. The GENERAL PHYSICS curriculum is planned for those whose general ability is better than average and is to be offered in grades eleven or twelve. (For those who are exceptionally talented and motivated, the course in GENERAL PHYSICS may be offered earlier on advice of the school counselors.)

The ADVANCED PLACEMENT PHYSICS is to be offered to students who have had the course in GENERAL PHYSICS and have demonstrated exceptional ability. The course is to be offered in grade twelve. The students enrolled must have been trained in mathematics through trigonometry and, if possible, have had some calculus. Students who succeed in the course can pass Advanced Placement Examinations given by colleges and universities to receive college credit or advanced standing.

As progress is made in the scientific world and in teaching techniques, these curriculum guides will require further development. In the meantime, they should serve the teachers involved in answering the need for more training in physics for our high school students.

PHYSICS: GENERAL

OVERVIEW

The universe in which we live and of which we are a part, whether viewed as a microcosm or as a macrocosm, presents to the inquiring mind almost an infinite field for study and adventure. Physics offers us one of the facets which is fundamental to the appreciation of the other sciences and of many of the everyday experiences. As we travel in our intellectual activity between the atom and the galaxies, life's paths can be more and more satisfying. A study of physics can be of practical value, can present esthetic pleasures, and can nurture the healthy curiosity which the high school student naturally has. Today's world is being molded by science. Physics still has much to do with this molding process.

GENERAL OBJECTIVES

What are the General Objectives of Physics?

An effective course of study in the field of physics which meets the needs of an atomic age, an age of space relationship, or an age which uses modern energy for peace, would include experience programs which deal with matters of vital concern, The objectives considered most desirable are:

I. To teach the students to think critically, using the scientific method as a basis for intelligent thought and action in solving problems of the group.

II. To discover and stimulate scientific ability and interest.

III. To help the student understand and master the basic physical laws.

IV. To make practical applications of what is learned.

V. To understand man's place in the universe; associate the contributions of science with the progress, security, and freedom of the world; and make clear the responsibility of society.

VI. To use scientific discoveries wisely

SPECIFIC OBJECTIVES

Unit I. Matter and Energy

This unit stresses the forms of energy, their differences, uses and resources. Scientists have recently discovered that matter can be changed into energy to produce enormous power. Since physics is the study of matter and energy and the physical changes in matter, we need to start by learning the fundamentals of the nature of matter and energy. We need also at this time an introduction to the metric system and measurement.

Unit II. Mechanics of liquids and gases

Liquids and gases are both classed as fluids. From a study of fluids we can develop concepts of force, pressure, density, and specific gravity. We can better understand the operation of the hydraulic press, hydrometer, barometer,

aqueducts, air pump, and baseball curves. We should become familiar with Pascal's Law, Archimede's Principle, Torricelli's Principle, Boyle's Law and Bernoulli's Principle. Later we should see how many of these principles are applied to aerodynamics.

Unit III. Molecular Physics

Matter is composed of molecules, which are in a constant state of motion. This molecular motion is found in liquids, gases, and even solids. Molecules are also subject to forces, an understanding of which leads to many practical applications of factual knowledge in physics.

Unit IV. Force and Motion

The works of Galileo and Newton are essential as we study forces and motion. We will be studying about velocity, acceleration, falling bodies, gravitation, centrifugal and centripetal forces, momentum, action and reaction, and aerodynamics. We should learn how to represent forces graphically. We should observe that the principles of physics have many practical applications.

Unit V. Work, Power and Energy

Work, power and energy have an interrelationship in that power and energy are defined in terms of work. All of us should be concerned with energy sources and with the development of new ones replacing those now being depleted. Without energy sources our machines would be useless and civilization, as we know it, would crumble.

Unit VI. Machines

Man's development to his present level of achievement is mainly due to the present high level of mechanical development. This results, in part, from man's invention and development of machines and energy sources to power machines to do work. Complex machines are really the result of combinations of simple machines. We can learn the basic concepts from simple machines and make application to the more complicated ones.

Unit VII. Heat

The study of the heat unit has more significant meaning in the atomic age than ever before. Some day we may be directly dependent upon nuclear and solar energy. All sources of heat are the result of energy transformation, so we again have our conservation of mass-energy. We need to be much concerned with the development of "modern" energy resources.

Unit VIII. Sound

Inasmuch as we are surrounded by sounds, we should try to understand more about them and their limits to the human ear. We should learn that sound travels through various media with different velocities, for different temperatures. The concepts developed through the study of sound overlap other areas of physics as evidenced by such terms as velocity, frequency, waves, resonance, and "sound barrier". Some sounds are pleasant, such as music; others are unpleasant, such as noise; but we must learn to live with all of them.

Unit IX. Light

Light gives us the opportunity to appreciate the marvelous concepts associated with the tremendous speed of light, the spectral colors, and the miracle of seeing. There are many practical applications of our light concepts such as eye-glasses, mirrors, and "light conditioning". The world would indeed be a drab place without light.

Unit X. Electricity

Magnetism and electricity are so important to us that we need to find out about some of the physics concepts which enable us to utilize them so efficiently. In order to have electrical energy, usually some form of chemical or mechanical energy is transformed. The practical values of our study of the interrelationship of magnetism and electricity show up in electric motors. Other concepts lead us to a better understanding of batteries, electric light, electric power, electrolysis, and electroplating.

Unit XI. Modern Physics

In modern physics some of the newer adaptations of electronics and nucleonics are outlined in part. Through necessity, the material for study included cannot cover all of our modern physics concepts. It is hoped that sufficient interest will be developed through this unit to encourage the student to develop further his scientific knowledge and interests.

METHODS, PROCEDURES, AND TECHNIQUES

I. Teach students to study, giving some idea of times and places where study can be done.

II. Emphasize the importance of the vocabulary used in physics.

III. Teach students the use of desired materials and methods for keeping a notebook. This may include the write-ups of pupil experiments as well as teacher demonstrations.

IV. Make an assignment at the beginning of each class period. If progress during the period indicates that the assignment needs modification, make this modification before the end of the period.

V. Have as many pupil-laboratory experiments as time and equipment will permit.

VI. Assign the solution of problems that are appropriate to the abilities of the student. Problem-solving is especially important to those students who are going to college.

VII. Teach the correct and safe way of doing experiments.

VIII. Plan adequate time after the regular school day for helping individual students.

IX. Encourage the most talented students to do special projects. These may be done after school or at home. In some cases it might be advisable for pupils to work independently on these projects during class time.

X. Encourage the use of various textbooks, magazines, and newspapers.

XI. Be sure that equipment is ready for demonstrations and pupil experiments before the class convenes.

XII. Use visual aids. Place your order in the office of the Audio-Visual Department as far as is possible in advance of the desired delivery date. This will increase your chances of having the materials on the day that you need them.

XIII. Plan tests well in advance, making sure that they are of high quality and meet the needs of the students.

XIV. Keep a "want list" so that you can make requisitions for the materials and apparatus needed.

XV. Provide for "changes of pace" to keep the students from becoming bored. Keeping the student's interest will do much to prevent discipline problems.

XVI. Be a good housekeeper. This will help to keep apparatus from disappearing and will also be good training for the student.

OUTLINE OF COURSE

While a time schedule for each unit is being suggested, the teacher's judgement should be allowed to make changes in time and/or order. In some cases, even omissions might be made. A few factors that make changes advisable are College Board Examinations, laboratory equipment and supplies available, the interests and preparation of the teacher, the type of neighborhood from which the pupils come, class size, and time available for student laboratory work.

		Weeks
Mathematics	Refresher	1
Unit I.	Matter and Energy	1
Unit II.	Mechanics of Liquids and Gases	4
Unit III.	Molecular Physics	1
Unit IV.	Force and Motion	5
Unit V.	Work, Power and Energy	3
Unit VI.	Machines	2
Unit VII.	Heat	4
Unit VIII.	Sound	2
Unit IX.	Light	4
Unit X.	Electricity	9
Unit XI.	Modern Physics	2
	Total	38

Semester 1, First six units
Semester 2, Units seven to eleven

Code: * Student Activity
Teacher Enrichment
#* Teacher or Selected Pupil Demonstration

PHYSICS: GENERAL

Unit One: Matter and Energy

OUTLINE OF CONTENT	EXPERIMENTS AND RELATED ACTIVITIES
I. What Are Matter and Energy?	Suggested vocabulary:

atom	nucleus
molecule	nuclear change
electron	chemical change
neutron	chemical element
proton	physical change

A. What is matter?

B. What is energy?
* Define matter and energy.

C. What are the major units of physics?
* Make a list of the major units of physics.

D. Of what are molecules composed?
* Make a diagram of a water molecule.

E. Of what are atoms composed?
* Make a list of the things of which atoms are composed.

1. Electron
2. Proton
* Make a diagram of a hydrogen atom.

3. Neutron
* Make a diagram of a helium atom.

F. What kinds of changes occur in matter?
* Make lists of examples of these three kinds of changes.

1. Physical
2. Chemical
3. Nuclear

II. What Are The Properties Of Matter?

Suggested vocabulary:

fluid	impenetrability
weight	porosity
mass	viscosity
density	weight

A. What are the phases of matter?
* Make a list of each of these three phases.

1. Solid
2. Liquid
3. Gas
* Perform a standard experiment on density.

B. What are the names of some of the properties of matter?

1. Mass
2. Weight
3. Volume
4. Viscosity
5. Porosity
6. Impenetrability

* Make lists of examples of substances that have one or more of these six properties.

C. What systems of measurement are in use?

1. English
2. Metric

* Practice until you can handle units based on a decimal system or relationship.

* In each of these systems give examples of units of length, area and volume.

* Measure objects using both English and Metric units.

D. What are some units in which a scientist might measure time?

* Make a list of these time units using the decimal prefixes.

E. What are some units of mass and weight?

* Make a list of units of mass and weight.

F. What is meant by density?

* Define density.

* Make a list of several ways in which density can be expressed.

Suggested Visual Aids:

Motion Picture Films:

Energy and Its Transformations
Introductions to Physics
Vernier Scale

PHYSICS: GENERAL

Unit Two: Mechanics of Liquids and Gases

OUTLINE OF CONTENT	EXPERIMENTS AND RELATED ACTIVITIES
I. What Are Liquid Pressure and Total Force?	Suggested vocabulary: force — direct and inverse proportions pressure — mechanical advantage buoyant force — water head total force specific gravity
A. What is liquid pressure?	
B. What is total force?	* Define liquid pressure and total force.
C. How does the pressure change as the depth changes?	#* Demonstrate by putting water in a container that has holes in the side at various depths.
D. What causes liquids to exert buoyant forces?	* Make a graph of pressure against depth.
E. To what extent does the shape of a container affect the pressure at a given depth in a liquid?	* Perform standard experiments in Archimedes' Principle for submerged and floating objects.
	* List applications of Archimedes' Principle.
F. What is Pascal's Principle?	# Demonstrate Pascal's Vases.
G. What are weight density and specific gravity?	* Consult textbooks and reference books to find applications of Pascal's Principle.
	* Perform standard experiments in determining specific gravities of solids and liquids.
II. How May We Study The Atmosphere and Weather?	Suggested Vocabulary: barometer — ionosphere aneroid — isobar altimeter — stratosphere front — troposphere chemosphere — tropopause exosphere — station model standard temperature — standard pressure
A. How do we know that air has weight?	#* Take a field trip to a weather bureau office.

#* Set up a weather observation center at or near your school.

* Keep a record of the weather and compare your records with the weather bureau forecasts; try making forecasts using your weather observations.

#* Weigh a baroscope before and after the air is pumped out.

B. How do we know that the atmosphere exerts pressure?

#* Using a bell jar with opening at the top, fasten sheet rubber over the opening and then pump the air out of the bell jar.

C. How can we make a barometer?

#* Demonstrate Magdeburg hemispheres.

Demonstrate the Torricellian tube.

D. What is an aneroid barometer?

* List practical applications of the aneroid barometer.

E. What happens to the mercury in a Torricellian tube when the atmospheric pressure is reduced?

Demonstrate using tall bell jar over a Torricellian tube. Pump air out from the bell jar.

F. How are weather maps made?

* Collect and study the weather maps from a newspaper for a month.

III. How Do We Study Expansion and Compression Characteristics of Gases?

Suggested vocabulary:

Boyle's Law
standard temperature
standard pressure

A. What is Boyle's Law?

#* Perform a standard Boyle's Law experiment.

B. How are vacuum pumps constructed?

* Make a graph of your Boyle's Law data.

C. How are pressure pumps constructed?

D. What are some of the uses of vacuum pumps?

* List some uses of vacuum pumps.

E. What are some of the uses of compressed air?

F. How are the various kinds of water pumps constructed?

1. Lift pump
2. Force pump
3. Centrifugal pump

G. How do siphons operate?

1. Intervening height
2. Direction of flow

H. Why do airships stay aloft?

I. How does a gas meter operate?

* Learn to read the gas meter in your home.

Suggested Visual Aids:

Motion picture films:

"Air in Action"
"Compressed Air Power"

Unit Three: Molecular Physics

OUTLINE OF CONTENT	EXPERIMENTS AND RELATED ACTIVITIES
I. What is the Kinetic Theory?	Suggested vocabulary:

adhesion	theory
cohesion	kinetic theory
diffusion	osmosis
absorption	surface tension
evaporation	tensile strength
capillarity	stress
brittle	strain
ductile	solvent
malleability	solute
hard	solution
elasticity	meniscus

A. How do molecules behave?

1. Gases
2. Liquids
3. Solids

Demonstrate the Brownian movement.

B. Why do gases change in volume?

1. Expand
2. Contract
3. Diffuse

Demonstrate diffusion through a porous cup.

Demonstrate osmosis.

Demonstrate liquid diffusion.

C. How do we classify the forces of attraction between molecules?

1. Adhesion
2. Cohesion

Demonstrate adhesion of chalk to the chalkboard.

Demonstrate the cohesion of iron for iron in an iron wire.

II. What are Some of the Characteristics That Substances Have Due to Molecular Forces?

A. Tensile Strength

B. Ductility

C. Malleability

D. Hardness

E. Brittleness

F. Elasticity

G. Surface tension

* Make a list of the way these properties are used in the materials in an automobile.

#* Perform an experiment to determine the tensile strength of a wire.

* Perform a standard Hooke's Law experiment.

#* Experiment with soap bubble films.

III. What Is Capillary Action?

Demonstrate capillary tubes in water and in mercury.

IV. What Happens When One Substance Goes Into Solution in Another Substance?

* Explain in your own words, what happens when one substance goes into solution in another.

V. How Are the Changes of State Affected by Solutions?

VI. What Is Henry's Law?

* Explain the importance of Henry's Law to the soft drink industry.

Suggested Visual Aids

Motion picture films on Molecular Theory of Matter.

Unit Four: Force and Motion

OUTLINE OF CONTENT	EXPERIMENTS AND RELATED ACTIVITIES
I. What Is Force?	Suggested vocabulary:

force	translatory motion
friction	vector quantity
resultant force	center of gravity
torque	equilibrant force
vector	parallel forces
pound	
equilibrium	
rotary motion	

coefficient of friction
resolution of forces
composition of forces
scalar quantity

A. What two things do forces do or tend to do?

1. Push
2. Pull

* Measure some forces using spring.

B. How may one find the resultant of two or more concurrent forces?

* Perform Standard experiment on composition of forces.

* Find resultants and equilibrants of force combinations using graphic methods.

C. How may one find the components of a given force?

#* Demonstrate the experimental and graphic methods showing the process of resolutions of forces.

* Apply the processes of composition and resolution to navigation problems.

D. What is necessary to have an object in equilibrium?

* Perform standard experiment with parallel forces.

E. What is center of gravity?

Demonstrate center of gravity in several different kinds of objects.

F. What are the three types of equilibrium?

1. Stable
2. Unstable
3. Neutral

Demonstrate and discuss the three types of equilibrium.

G. What is friction?

1. Starting
2. Sliding
3. Rolling

* List examples of the helps and hindrances that can be caused by friction.

II. What is Motion?

Suggested vocabulary:

A. How may we measure motion?

B. How does speed differ from velocity?

C. What is acceleration?

speed
velocity
motion
mass
inertia
momentum
rectilinear
gravitation
centripetal
centrifugal
impulse
pendulum
acceleration

#** Perform uniform acceleration experiment using available apparatus.

Demonstrate the fall of a coin and feather in a vacuum.

Demonstrate the rate of fall of a body that has horizontal motion.

* Graph the trajectory of a projectile that is fired at an angle that is less than 90 degrees from the horizontal.

D. What are Newton's three laws of motion?

1. First law
2. Second law
3. Third law

* Make a list of applications of the first law in athletic events. Do the same for automobile and airplane travel.

* Find how the second law is used in athletic events, vehicular travel, and in rocketry.

E. What is Newton's Law of Universal Gravitation?

* List the things determining the amount of gravitational attraction between objects.

* Describe how gravitational attraction differs on the moon and on planets.

F. What forces are involved in circular motion?

1. Centrifugal
2. Centripetal

* List the forces which are involved in keeping our solar system in its present state of arrangement.

* Make a list of appliances in the home and in industry that involve circular motion.

G. What is periodic motion?

* Perform a standard experiment with a pendulum.

H. How does the motion of a fluid affect the forces that it exerts on objects?

* Make a list of the four laws of the pendulum.

* Make a statement of Bernoulli's principle.

* Make a list of practical applications of Bernoulli's principle in games and in the automobile.

* Describe the application of the Bernoulli principle to the support and control of an airplane.

Suggested Visual Aids:
Jet Propulsion
Laws of Motion
Lift
Theory and Problems of Flight

Unit Five: Work, Power and Energy

OUTLINE OF CONTENT	EXPERIMENTS AND RELATED ACTIVITIES
I. What Is The Scientific Meaning of the Word "Work"?	Suggested vocabulary: work potential energy kinetic energy power
A. What must a person do to work on an object?	# Demonstrate the work done in lifting one-pound weight a distance of one foot.
B. How can work be measured?	# With a spring balance, drag the one-pound weight a distance of one foot along the table top and then compute the work done.
	# Show why practically no work is done when one pushes on the wall of the room.
II. How Do We Define the Word "Power"?	#* Perform a standard experiment in the determination of the horse power of pupils by having them run up a stairway.
III. What Are The Types Of Energy?	* Compute the kinetic energy of an automobile that is moving at high speed.
A. Potential	
B. Kinetic	* From the standpoint of kinetic energy, show why it is unsafe to drive an automobile at high speed.
IV. What Is The Relationship Between Mass and Energy?	* Find the method of determining the amoung of energy that is equivalent to a given amount of mass.
	# Show a motion picture film on the subject of atomic energy.
V. How Does the Motion of a Given Mass Affect the Amount Mass?	* Learn to give the amount of mass an object will have at various speeds.
Suggested Visual Aids: Diesel, The Modern Power Steam for Power	

Unit Six: Machines

OUTLINE OF CONTENT	EXPERIMENTS AND RELATED ACTIVITIES
I. What are the General Principles of Machines?	Suggested vocabulary: lever, inclined plane, screw, wedge, pulley, wheel and axle, output, input, efficiency, water turbine, mechanical advantage
A. What three things can machines do for us?	# By using a bench vise, demonstrate the multiplication of force.
1. Force at the expense of speed 2. Speed at the expense of force 3. Direction change	# By using a fish pole or a meter stick, demonstrate the multiplication of speed. # By using a single fixed pulley, demonstrate the change of direction.
II. What are the Six Simple Machines?	
A. Lever	# Perform a standard experiment on the lever.
B. Pulley	* Perform a standard experiment on the pulley.
C. Wheel and axle	#* Perform an experiment with the wheel and axle.
D. Inclined plane	* Perform a standard experiment with the inclined plane.
E. Screw	#* Demonstrate the screw with a jack-screw.
F. Wedge	# Demonstrate the wedge.
III. What must we Know about a Machine to Find its Efficienty?	# Measure the output of a commercial block-and-tackle.
A. Output	# Measure the input of a block-and-tackle that was used in the item above.
B. Input	* Compute the efficienty of the block-and-tackle.
IV. What are Some Examples of the Practical Applications of Machines?	# Show a motion picture of the simple machine.
A. Lever of the first class	# Take the class on a field trip to a shop or factory where machines are used.
B. Lever of the second class	

C. Lever of the third class

D. Pulley

E. Wheel-and-axle

F. Inclined plane

G. Screw

H. Compound machines

#* Construct a compound machine using the simple machines in the laboratory.

V. How does A Water Turbine do Work for Us?

#* If possible, take the class on a field trip to a hydro-electric power generating station.

Show a film on water power.

VI. How is Mechanical Power Transmitted from one Place to Another?

* Using the autombbile as an example, make a list of the devices that transmit the power from the engine's pistons to the rear wheels.

A. Belts

B. Shafts

C. Gears

D. Liquids

Suggested Visual Aids:
Simple Machines

Unit Seven: Heat

OUTLINE OF CONTENT	EXPERIMENTS AND RELATED ACTIVITIES
I. How are Temperature and Heat Related?	Suggested vocabulary: temperature, thermal energy, heat, thermometer
A. What sources of heat exist?	* List common fuels and write a paragraph explaining the origin of the energy now stored within them.
1. Sources outside the earth	
2. Sources on the earth	* List the source of heat in geysers, hot springs, and volcanoes.
B. How is temperature measured?	* Read temperatures from a thermometer placed as follows: Inside the room, outside the window, in direct sunlight, in melting ice or snow, in boiling water.
1. Use of thermometers	
2. Construction of thermometers	#* Make and demonstrate a mercury and a gas thermometer.

C. How is the temperature of boiling water affected by pressure?

Demonstrate with appropriate apparatus.

1. Effect of increased pressure

* Compare boiling point temperatures on mountain tops with those at sea level.

2. Effect of decreased pressure

II. How is Expansion of Matter Related to Heat?

Suggested vocabulary:

thermal expansion
absolute zero
bimetallic strip
coefficient of linear expansion
coefficient of volume expansion

A. How can we know that solids change in size when the temperature changes?

* Examine bridges and viaducts for dimension changes in summer and winter.

1. Expansion when heated

2. Contraction when cooled

* Perform ball and ring experiment.

B. What happens to bimetallic strip with changes in temperature?

Demonstrate with bimetallic strip using Bunsen burner and ice water.

1. When heated

* List the ways bimetallic strips are used in science and industry.

2. When cooled

C. What happens to volumes of liquids with temperature changes?

Demonstrate by heating ice water in appropriate equipment.

Demonstrate by heating water that is warmer than 4 degrees centigrade.

D. What happens to the volume of gases with temperature change?

* Perform Charles Law experiment.

III. Under what Conditions does Matter Change in State?

Suggested vocabulary:

calorie
dew point
fusion
heat capacity
heat of fusion
humidity
British thermal unit
heat of vaporization.
specific heat
sublimation
vaporization

A. In what units do we measure heat?
   * List the units in which heat is measured.

   1. British units

   2. Metric units

B. How can we show that different substances have different heat capacities?
   * Perform specific heat experiment, using method of mixtures.

   1. Iron

   2. Aluminum

   3. Zinc

   4. Lead

C. How do the volumes of substances change when they solidify?
   * Freeze a bottle full of water.

   1. Water

   2. Paraffin
      * Allow paraffin to solidify in a bottle.

D. How much heat is required to melt a gram of ice?
   * perform heat of fusion experiment using ice and method of mixtures.

E. What kinds of substances vaporize?

   1. Liquids
      * Observe the evaporation of water.

   2. Solids
      * Observe evaporation of moth balls.

F. What factors affect the rates of evaporation of liquids?

   1. Temperature
   2. Free surface area
   3. Circulation of air above free surface
   4. Kind of liquid

   * Perform experiments to observe these four factors.

G. How many calories are required to vaporize a gram of water at the boiling point?
   * Perform heat experiment for water using the method of mixtures.

H. What is involved in distillation?

   1. Vaporization
   2. Condensation

   #* Demonstrate the distillation of ordinary drinking water.

I. How are gases, including those in the atmosphere, liquefied?

* Describe methods of liquefying gases.

J. How does the mechanical refrigerator work?

* Describe the essential processes in mechanical refrigeration.

1. Condensation
2. Evaporation

K. How de we determine the humidity and dew point of the atmosphere?

* Describe the processes of measuring humidity and dew point.

1. Absolute
2. Relative
3. Dew point

#* Take field trip to weather station.

#* Use hygrodeik.

L. What factors affect moisture precipitation in the atmosphere?

* Describe the factors that affect moisture precipitation in the atmosphere.

1. Relative humidity
2. Remperature
3. Particles

IU. How does Heat get from one Place to Another?

Suggested vocabulary:

conduction
convection
radiation
conditioned air

A. By what methods does heat transfer take place?

1. Conduction

Demonstrate using a conductometer.

2. Convection

Demonstrate convection in water and air.

* Describe movements of the atmosphere.

3. Radiation

Demonstrate radiometer in direct sunlight.

Demonstrate radiation from red hot metal.

B. In what ways does heat move from place to place in our homes?

* Describe the uses of home insulation.

1. Natural ventilation
2. Conditioned air
3. Space heaters
4. Unit heaters
5. Forced hot air heating
6. Circulating hot water heat
7. Steam heating systems
8. Heat pump

* Find the advantages and disadvantages of the various kinds of heating and air-conditioning systems.

C. What is involved in the vacuum bottle?

1. Conduction
2. Convection
3. Radiation

* Diagram a vacuum bottle.

* Describe the way in which heat gets from the sun to the earth.

V. How are Work and Heat Related?

Suggested vocabulary:

Mechanical equivalent of heat
internal combustion engine
external combustion engine

A. Can work be changed to heat and vice versa?

1. Automobile brakes
2. Automobile engines
3. Steam engines
4. Mechanical equivalent of heat

B. How is steam produced for a steam engine?

1. Fire-tube boiler
2. Water-tube boiler

* Describe boiler construction.

C. How efficient are steam engines?

1. Reciprocating
2. Turbine

Conduct field trip to power plant.

* Describe construction of steam turbines.

D. How are gasoline engines constructed?

1. Four-stroke
2. Two-stroke
3. Diesel

Conduct field trip to automobile repair shop.

* Describe construction of gasoline engines.

E. How do gasoline engines operate?

1. Four-stroke
2. Two-stroke
3. Diesel

* Compare stroke cycles of four-stroke, two-stroke, and diesel engines.

F. How are turbines constructed?

1. Gas
2. Turbo-jet

* Describe the construction and operation of gas turbine engines.

G. How do turbines operate?

1. Gas
2. Turbo-jet

*

H. Upon what principle does the rocket operate?

* Describe how rockets are constructed, and where they are used.

I. How is a rocket constructed?

Suggested Visual Aids:

Distributing Heat Energy
Heat and Its Control
Thermodynamics

Unit Eight: Sound

OUTLINE OF CONTENT	EXPERIMENTS AND RELATED ACTIVITIES

I. What are Wave Motions and their Characteristics?

Suggested vocabulary:

wave length	pitch
transverse wave	echo
longitudinal wave	beat
frequency	interference
intensity	infrasonic
loudness	ultrasonic
	resonance

A. How are sounds produced?

1. Tuning fork
2. Door bell
3. Whistle

* Fasten a meter stick in a bench vise and cause it to vibrate.

B. Through what media may sound travel?

* Hold the ends of a low-pitch, vibrating tuning fork in water.

1. Solids
2. Liquids
3. Gases

* Hold vibrating tuning fork against a door panel and place finger tips against door panel.

* Listen for sounds while under water in a swimming pool.

Perform conventional demonstration with alarm clock under an evacuated bell jar.

C. What ear structure makes it possible for us to hear sounds?

* Examine the chart of the ear in text-book or a reference book.

1. Outer ear
2. Middle Ear
3. Inner ear

Conduct discussion of situation when a tree falls in an area where there are no people or animals close enough to hear waves produced by a falling tree.

D. In the physiological sense, what things are necessary for the production of sound?

E. How can we measure the speed of sound?

1. Direct measurement
2. Resonant air column method

#* With gun and stop watch make measurement in open country.

* Perform experiment with resonant air column.

F. What are two kinds of wave motions?

1. Transverse
2. Longitudinal

#* Observe water waves through side of an aquarium.

Show motion picture on sound waves.

G. How can frequency of a sound wave be calculated?

* Solve problems using the formula: velocity equals frequency multiplied by wave length.

H. What echoes are useful?

1. Sonar
2. Seismic
3. Music rooms

I. Where are echoes harmful?

1. Arenas
2. School corridors
3. Gymnasium

* Listen for echoes in unoccupied corridor, auditorium, or arena.

J. How may sounds differ?

1. Intensity
2. Loudness

* Describe the relationship of intensity to loudness.

K. How may frequency be measured?

1. Vibrograph
2. Motorized siren

Demonstration of methods of measuring frequency.

L. How can the Doppler effect be detected?

* While passing a parked car that is sounding its horn, listen for the change in pitch.

M. What sounds are inaudible?

Demonstrate the Galton Whistle.

N. What is resonance or sympathetic vibration?

Demonstrate resonant tuning forks or resonant bars.

O. How can we show that sound waves interfere with one another?

Demonstrate beats with forks or bars that are of slightly different frequencies.

II. What is Music and How De We Produce It?

Suggested vocabulary:

Tone	major chord
fundamental tone	chromatic scale
overtone	diatonic scale
noise	tempered scale
quality	

A. How does a musical tone differ from noise?

B. What are a major chord, diatonic scale, chromatic scale, and tempered scale?

Using a microphone and oscilloscope, demonstrate music and noise patterns.

C. What are harmony and discord?

#* Demonstrate scales, harmony, and discord on a school piano.

D. What determines tone quality?

Demonstrate fundamental tones and overtones on a long rubber tubing and by bowing a sonometer string.

E. What determines the frequency of a vibrating string?

Demonstrate the laws of vibrating strings using a sonometer.

1. Length
2. Diameter
3. Tension
4. Density

F. What are the kinds of instruments used in making music?

Visit instrumental music class.

G. The phonograph record industry is interested in what two kinds of equipment?

1. Record making
2. Record playing

* Examine a phonograph record under a magnifying glass.

Conduct discussions of the making of phonograph records and tape recordings.

Conduct discussions of the operation of phonograph record players and of tape recording players.

H. How do dictating machines operate?

#* Visit a business office where dictating machines are used.

Suggested Visual Aids:

Fundamentals of Acoustics
Science in the Orchestra
Sound Waves and Their Sources
Voice that Science Made
Development of Communication

Unit Nine: Light

OUTLINE OF CONTENT	EXPERIMENTS AND RELATED ACTIVITIES
I. What is the Nature of Light?	Suggested vocabulary:
	illuminated, opaque, translucent, transparent, luminous, candle, photometer, lumen, micron
A. How do sound and light waves differ?	
1. Transverse 2. Very short 3. Travel through vacuum	
B. From what kinds of objects does light reach our eyes?	* In a mathematics book, review the meanings of inverse proportion and of the square of a number.
1. Luminous 2. Non-luminous	* Make diagrams to show eclipses of the sun and moon.
C. How do we measure light?	* Explain the causes of shadows.
1. Luminous source 2. Illumination of a surface	* Describe the ways of measurement of light speed.
	* Perform a standard photometry experiment.
	* Describe our light needs.
II. How is Light Reflected?	Suggested vocabulary:
	normal, convex, concave, focus, real image, spherical aberration, angle of incidence, angle of reflection, virtual image
A. From what kinds of surfaces is light reflected?	
1. Rough 2. Polished	
B. How can light be diffused?	# Show a motion picture on the behavior of light.
1. Reflection 2. Transmission	* Perform a standard experiment with a plane mirror.

C. What are the two kinds of curved mirrors?

1. Convex

* Perform a standard experiment with a convex mirror.

2. Concave

* Perform a standard experiment with a concave mirror.

D. What are the two kinds of images?

1. Virtual
2. Real

* Practice the construction of ray diagrams to determine the characteristics of images of objects that are in front of plane and curved mirrors.

III. How is light refracted?

Suggested vocabulary:

Angle of refraction
index of refraction
critical angle
optical density

A. Under what conditions is light refracted?

1. Optical density change

2. Oblique entry at the dividing surface.

* Study the three laws of refraction.

* Perform standard experiment on refraction.

B. What are some of the substances that can refract light?

#* Observe the refractions and reflections that can be produced by a water-filled aquarium.

1. Atmosphere
2. Glass
3. Water

C. What are the two classes of lenses?

* Demonstrate the refraction of light by prisms and lenses using an optical wheel and appropriate light source.

1. Converging
2. Diverging

D. What kinds of images can be produced by lenses?

* Practice the construction of images using ray diagrams for convex and concave lenses.

1. Real
2. Virtual

IV. What is the Nature of Color?

Suggested vocabulary:

solar spectrum
continuous spectrum
dispersion
diffraction
interference
monochromatic light
line spectrum
absorption spectrum
chromatic aberration
complementary colors

polychromatic primary colors
light
primary pigments

A. What determines the color of light?

1. Wave length
2. Frequency

* Diagram the passage of sunlight through a triangular prism. Label the colors produced.

B. What determines the color of an object?

1. Wave length reflection
2. Wave length absorption
3. Wave length transmission

Show a film on the nature of color.

C. What are the kinds of spectra?

1. Continuous
2. Line
3. Absorption

* Describe the effects of mixing light rays, pigments, and the process of color printing and color photography.

Demonstrate the various spectra using a spectroscope.

D. What are two kinds of aberrations?

1. Spherical
2. Chromatic

* Look at objects through a cheap lens and note the aberrations.

E. What is interference?

#* Examine Newton's rings with appropriate equipment.

F. What is polarization?

#* Using polaroid lenses, examine light that passes through both lenses when slits are parallel to each other and again when they are at right angles to each other.

* Using one polaroid lens, examine light that has been reflected from a polished table top. Do the same for light from the Northern sky.

IV. How do Optical Instruments Work?

Suggested vocabulary:

retina
farsightedness
nearsightedness
astigmatism
accommodation
color blindness
duration of vision

A. How does the human eye operate?

1. Structure
2. Image formation
3. Color vision
4. Color blindness
5. Nearsightedness
6. Farsightedness
7. Astigmatism
8. Judgment of size

* Diagram the human eye and label its parts.

#* Place a student in a dark room for five minutes. Then turn on the light and observe the dilation of the

9. Judgment of distance

pupil of this person's eye.

* Select a person who is past middle age. Investigate his problem of reading without his reading glasses.

#* Examine class members for color blindness giving special attention to the boys.

Use an optical wheel and appropriate light source to demonstrate the correction of nearsightedness and farsightedness.

B. How does the camera operate?

#* If the teacher or member of the class wears glasses, try to determine what kind of eye defect is being corrected.

* Compare the construction and operation of the camera with that of the eye.

C. How does the simple magnifier work?

* Read some fine print through a reading glass.

D. How does a compound microscope work?

#* Construct a compound magnifier on an optical bench.

E. What are the types of telescopes?

#* If you are near an astronomy club, ask a member to demonstrate the telescopes.

1. Refracting
2. Reflecting
3. Erecting or terrestiral

F. How does the prism binocular work?

* Describe how prism binoculars work.

G. What is involved in motion pictures?

* Examine your school's sound motion picture projector.

1. Persistence of vision
2. Projection of picture
3. Sound on film
4. Depth
t. Sound reproduction

H. What does the spectroscope do for us?

#* Describe the uses of spectroscopes.

1. In industry
2. In science laboratory
3. In astronomy

#* Have a lecture demonstration by a camera fan.

I. What are the uses of polarized light?

* Describe the uses of polarized light in science and industry.

1. Sugar analysis
2. Stress analysis
3. Photography

Suggested Visual Aids:

Nature of Color
Heat and Light from Electricity
Behavior of Light

Unit Ten: Electricity

OUTLINE OF CONTENT	EXPERIMENTS AND RELATED ACTIVITIES
I. What is the Nature of Magnetic Effects?	Suggested vocabulary: Pole, North-seeking pole, field, magnetic line, permeable, induced magnetism
A. What substances are paramagnetic?	# Show polarity with magnet and iron filings.
1. Copper 2. Glass 3. Wood	# Suspend a bar magnet horizontally by a thread to show orientation.
B. What substances are diamagnetic?	# Test the polarity of a broken magnet.
1. Iron 2. Steel 3. Cobalt 4. Nickel	* Perform a standard experiment with iron filings on a sheet of paper which is resting on a magnet.
C. Is the earth a magnet?	# Use a globe to show the earth's magnetism.
1. Declination 2. Inclination	
II. What is the Nature of Static Electricity?	Suggested vocabulary: insulator, conductor, ion, capacitor, electroscope
A. What are the two kinds of electric charges?	#* Produce positive and negative charges.
1. Positive 2. Negative	# Identify charges.

B. How may electric charges be produced?

With electroscope and charges, identify insulators and conductors.

III. What is the Nature of Current Electricity?

Suggested vocabulary:

direct current	ampere
ohm	volt
series	ammeter
voltmeter	electromotive force

A. How can current electricity be produced?

1. Dry cells
2. Storage battery

#* Perform standard experiments using series and parallel circuits.

B. How is Ohm's Law used?

1. Resistance
2. E.M.F.
3. Current

#* Perform standard experiment using a Wheatstone bridge to measure resistance.

bIV. What are the Magnetic Effects of Electricity?

Suggested vocabulary:

electromagnet
helix

A. What is the nature of the magnetism near a straight conductor carrying a direct current?

1. Compass deflections above wire
2. Compass deflections below wire
3. Compass deflections around a vertical wire carrying a current.

* Perform a standard experiment exploring a magnetic field around a straight wire carrying a current.

* Study field around helix carrying current.

B. What is the nature of them magnetism near a helix carrying a current?

* Make an electromagnet.

* Take a field trip to a telephone company exchange.

* Show motion picture of magnetic effects of electric currents.

1. Poles
2. Iron core
3. Hand rule for determining polarity
4. Door bell
5. Door chime
6. Telegraph system
7. Telephone

V. How do we make Electrical Measurements?

Suggested vocabulary:

galvanometer	watt
kilowatt-hour	coulomb
galvanoscope	

A. How is a galvanometer constructed?

1. Electromagnetic helix
2. Permanent magnet
3. Spring
4. Pointer
5. Dial

#* Perform standard experiment measuring current through a resistance.

Using the same circuit, measure voltage across the various parts of the circuit.

B. How is an ammeter constructed?

Show motion picture of the uses of ammeters and voltmeters.

1. Electromagnet helix
2. Permanent magnet
3. Low resistance shunt

C. How is a voltmeter constructed?

1. Electromagnet helix
2. Permanent magnet
3. Coils of high resistance

D. How is a resistance box constructed?

1. Calibrated resistance coils
2. Plugs
3. Terminals

VI. What are the Chemical Effects of Electricity?

Suggested vocabulary:

voltaic cell cathode
anode electrolysis

A. What is electrolysis?

Perform demonstration of the electrolysis of water.

1. Cell
2. Electrolyte
3. Direct current source

B. How do we electroplate objects?

Show motion picture on electrochemistry.

1. Cell
2. Electrolyte
3. Anode of metal to be deposited
4. Conducting surface at cathode on which metal is to be deposited

C. How does a voltaic cell operate?

#* Make a voltaic cell and check its voltage.

1. Carbon electrode
2. Zinc electrode

3. Electrolyte
4. Electron flow in electrolyte
5. Electron flow in external circuit

D. What are the defects in a voltaic cell?

1. Polarization
2. Local action

E. What voltages can we get from a dry cell battery?

1. Series
2. Parallel

F. How does a lead storage battery operate?

1. Lead Plate
2. Lead dioxide plate
3. Water solution of sulfuric acid
4. Reversible chemical reaction
5. Current direction on charge and discharge.

#* Visit a battery shop to see how storage batteries are constructed and cared for.

VII. How Do We Change Electrical Energy To Heat and Light Energy?

A. How do we get heat energy from electrical energy?

1. Current
2. Resistance
3. Heating element in stove
4. Heating element in toaster

B. How do we prevent an overload?

1. Fuse
2. Circuit breaker

C. How do we get light energy from electrical energy?

1. Incandescent lamp
2. Flourescent lamp

Suggested vocabulary:

fuse
overload
short circuit

#Perform standard experiment to determine amperage, voltage, and wattage used by toaster.

#Show why a fuse is our best friend and should not be tampered with.

*Examine the construction of an unfrosted incandescent lamp bulb.

*Show motion picture on getting heat and light from electricity.

VIII. How Do We Produce And Use Induced Currents?

A. How can we produce an induced current using only a permanent magnet and a single coil of wire?

Suggested vocabulary:

primary coil
secondary coil
induction
generator
motor
self-induction
transformer
alternating current

1. Stationary coil, moving magnet
2. Stationary magnet, moving coil
3. Effect of speed on moving component

* Perform standard experiments to produce induced currents.

\# Show motion picture on induced currents and their uses.

B. How can one current induce another current?

1. Move primary coil
2. Interrupt primary current
3. Insert iron core in primary

C. What are the construction and uses of an induction coil?

\# Discuss Lenz's Law.

\# Drill on hand rules for determining directions of induced currents.

1. Primary coil
2. Iron core
3. Secondary coil
4. Vibrator
5. Capacitor
6. Dry cells
7. Automobile ignition system

\# Show a motion picture film on electro-dynamics.

\#* Examine automobile ignition system.

D. How are alternating and direct current generators constructed and used?

\#* Visit power plant to study generators and motors.

1. Permanent or electromagnet
2. Revolving coil
3. Iron core
4. Brushes
5. Slip rings
6. Commutator

\# Drill on hand rules for motor rotation directions.

\# Generate and discuss a power cycle.

E. How is a transformer constructed and used?

\#* Visit power plant or distribution center to see transformers in action.

1. Primary coil with changing or alternating current
2. Secondary coil and induced A.C.
3. Iron core, laminated
4. Effect of numbers of turns on primary and secondary coils and the respective voltages and amperages
5. Economy of power transmission
6. Securing desired voltages

\# Emphasize the importance of safety in using high voltages in factories and homes.

IX. What Are The Special Characteristics Of Alternating Currents And Their Circuits?

Suggested vocabulary:

inductance
inductive reactance
impedance
power factor

A. What is the current condition when a capacitor is connected in series in a circuit?

1. Steady direct voltage
2. Alternating voltage

Use standard equipment to demonstrate inductance and reactance.

B. What characteristics do A.C. circuits have when they include capacitance and inductance?

Discuss power factor.

1. Capacitance reactance
2. Inductive reactance
3. Currents out of step with voltages

C. How can A.C. be changed to D. C.?

Demonstrate a rectifier.

1. Dry-disk rectifier
2. Motor-generator
3. Rotary converter
4. Electronic tube

Suggested Visual Aids: Electrostatics, Electrodynamics, Electron, Making Electricity, Vacuum tubes, What is electricity, Magnetic effect of electricity

Unit Eleven: Modern Physics

OUTLINE OF CONTENT	EXPERIMENTS AND RELATED ACTIVITIES
I. How Do Electronic Tubes Work?	Suggested vocabulary: diode, cathode, plate, grid, triode, transistor
A. What are the elements of a diode vacuum tube? 1. Filament 2. Plate	* Describe the contributions that were made by Edison and Fleming.
B. What are the elements of a triode tube? 1. Filament 2. Grid 3. Plate	# Show a motion picture on vacuum tubes. #* Demonstrate use of vacuum tube using A battery,, B battery, and galvanometer in the plate circuit.
C. How does a tube rectifier work?	* Visit a battery shop to see how they get direct current for charging storage batteries.
D. How do we get light from gas tubes? 1. Neon signs 2. Flourescent lamps	
E. How can we show the bending of an electron beam by magnetism? 1. Cathode ray tube and magnet 2. Cathode ray tube and electromagnetic coil	# Show a motion picture on television receivers. # Describe the operation of television picture tubes.

F. How can we make simple triode circuits?

1. Amplifier
2. Oscillator
3. Crystal oscillator

* Describe how one can make simple triode circuits.

G. What are some other types of tubes?

1. Tetrode
2. Pentode

* List the names and uses of the parts of these tubes.

H. Why are transistors useful?

1. Small size
2. Low battery costs

* List reasons for using transistors

I. Why are oscilloscopes so useful?

1. To study sound
2. To study radio
3. To service radio and television sets

#* Take a field trip to a radio or television repair shop to see an oscilloscope in use.

J. What are some of the uses of electronics in industry?

1. Ignitron
2. Current for D.C. motors
3. Dielectric heating
4. Induction heating
5. Traffic counters
6. Door openers
7. Package sorters
8. Accident prevention
9. Manufacturing standards

* Describe the uses of electronics in science and industry.

K. What are the parts of an X-ray tube?

1. Cathode
2. Anode
3. Target

* Describe the three parts of an X-ray tube.

L. For what things are X-rays used?

* List the uses of X-rays.

M. Why is an electron microscope more effective than an optical microscope?

* Describe the effectiveness of the electron microscope.

N. For what do we use radar?

* List the uses of radar.

II. How Do Radio And Television Sending And Receiving Sets Work?

Suggested Vocabulary:

detector	amplitude modulation
antenna	frequency modulation
loudspeaker	carrier signal
microphone	megacycle
discriminator	image kilocycle
kilocycle	

A. Why must the carrier frequency be so great?

* Give the reason for the use of a high frequency carrier wave.

* Using the wave formula, solve problems changing frequencies to wave lengths.

B. What is amplitude modulation?

* Describe amplitude modulation.

C. How do radio receiving sets work?

Show motion picture to demostrate how radio broadcasing is done.

* Describe the way in which receiving sets work.

D. What is frequency modulation?

* Describe frequency modulation.

E. How are FM receivers different from AM receivers?

* Describe the difference between FM and AM receivers.

F. How are TV pictures and sound broadcast produced?

* Describe the broadcasting of TV pictures and sound.

G. How are TV pictures and sound received?

III. What Do We Know About Atomic Structure and Nuclear Energy?

Suggested vocabulary:

beta particle	cosmic rays
alpha particle	radioactivity
deuteron	fission
meson	fusion
gamma rays	chain reaction
positron	cyclotron

A. What is the structure of an atom?

* Describe the structure of atoms.

* Show motion picture on the structure of the atom.

1. Hydrogen
2. Helium
3. Sodium

B. What are isotopes?

1. Hydrogen
2. Deuterium
3. Tritium
4. Uranium

C. What is radioactivity?

Show film on atomic energy.

* Read the life of Mme. Curie.

1. Radium
2. Uranium

D. How do scientists increase the energy of atomic or nuclear particles?

* Discuss atomic fission and its control for peacetime purposes.

1. Van de Graaff generator
2. Cyclotron
3. Synchro-cyclotron
4. Synchrotron
5. Bevatron

E. What are cosmic rays?

* Describe cosmic rays.

1. Protons
2. Ions

Suggested Visual Aids:

A Is For Atom
Atomic Energy
Atomic Power
Atomic Radiation

TESTING AND EVALUATION

Tests are for the purpose of showing the pupil and the teacher how well the pupil is progressing. It also shows the teacher how well he is communicating. Tests are only one of the criteria upon which grades are based.

Objective tests have their advantages and their disadvantages. Essay tests have their advantages and their disadvantages. Tests should be of varying types. In part, the type of test may be determined by the nature of the subject matter being covered.

The accompanying objective test includes items that are true-false, multiple-choice, and problems. Tf you wish to preserve the test sheets, a suggested answer sheet is also included. The problems are also multiple choice, but no credit should be given unless the solution is clearly shown on the back of the answer sheet.

The graded test should be returned to the students as one of the phases for his self-evaluation. Here the student has the opportunity to raise questions. Further teaching should follow the determination of those items that were missed by a significant number of students. If the tests are to be used again, they and the answer sheets should be returned to the teacher. In summary, teach, test, and then teach again.

LIGHT REFRACTION AND IMAGE PRODUCTION

TRUE-FALSE

1. When light enters glass from air at right angles to the glass surface, no refraction occurs. (1) true (2) false.

2. Swimming pools appear to be more shallow than they really are. (1) true (2) false.

3. It is possible for a ray of light to strike the surface of glass at such an angle that it cannot come out of the glass into the air. (1) true (2) false.

4. High grade field glasses use silvered mirrors. (1) true (2) false.

5. When an object is placed on the principal focus of a convex lens, there is no real image produced. (1) true (2) false.

6. The image on the retina of the eye is erect. (1) true (2) false.

7. The eye's lens always has the same focal length. (1) true (2) false.

8. The apparant size of an object is, in part, determined by the visual angle. (1) true (2) false.

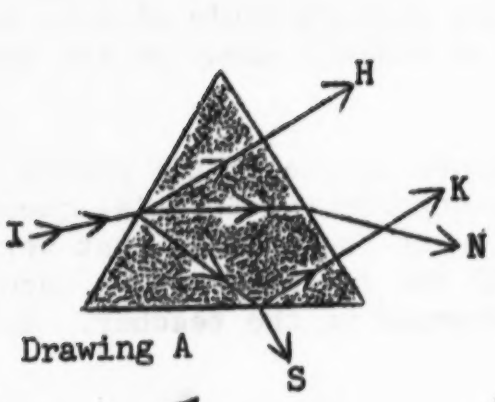
9. The image on the sensitive film of a camera is inverted. (1) true (2) false.

10. Compound microscope images are inverted. (1) true (2) false.

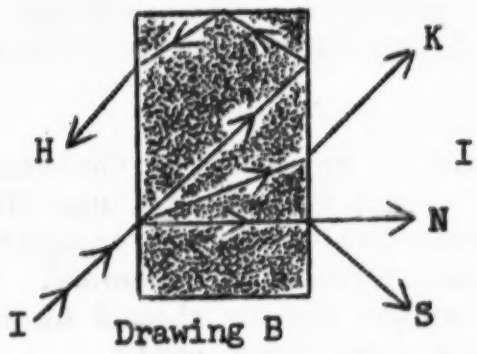
11. The opera glass forms an erect image directly on the retina of the eye. (1) true (2) false.

12. Motion picture images are inverted. (1) true (2) false.

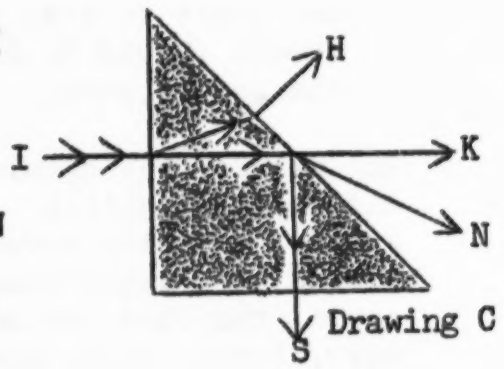
MULTIPLE CHOICE



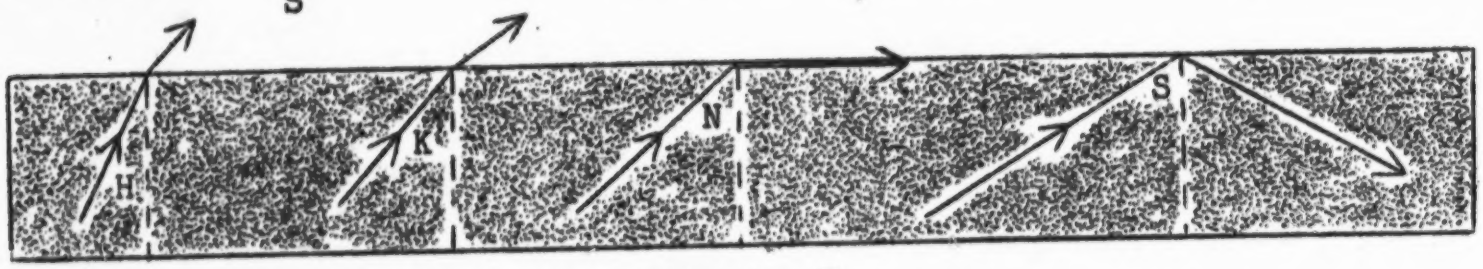
Drawing A



Drawing B



Drawing C



Drawing D

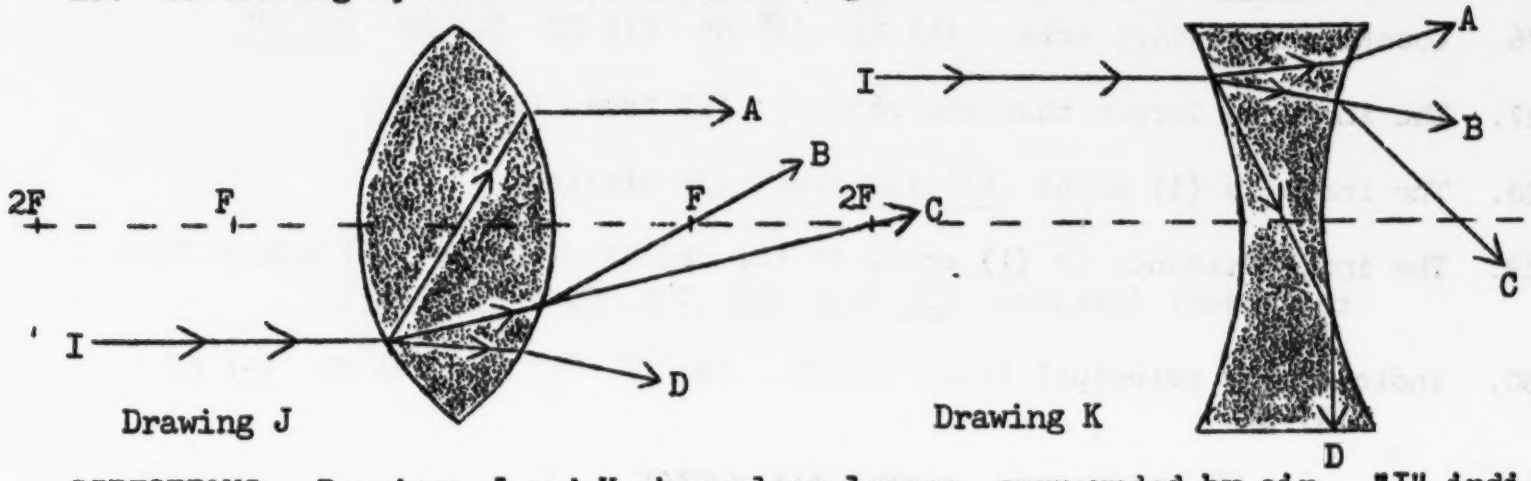
DIRECTIONS: Drawings A, B, C, and D are glass prisms surrounded by air. Incident rays are labled "I." By selecting letters, trace the ray's paths through the prisms.

13. In drawing A, the path is (1) H (2) K (3) N (4) S.

14. In drawing B, the path is (1) H (2) K (3) N (4) S.

15. In drawing C, the path is (1) H (2) K (3) N (4) S.

16. In drawing D, select the critical angle. (1) H (2) K (3) N (4) S.



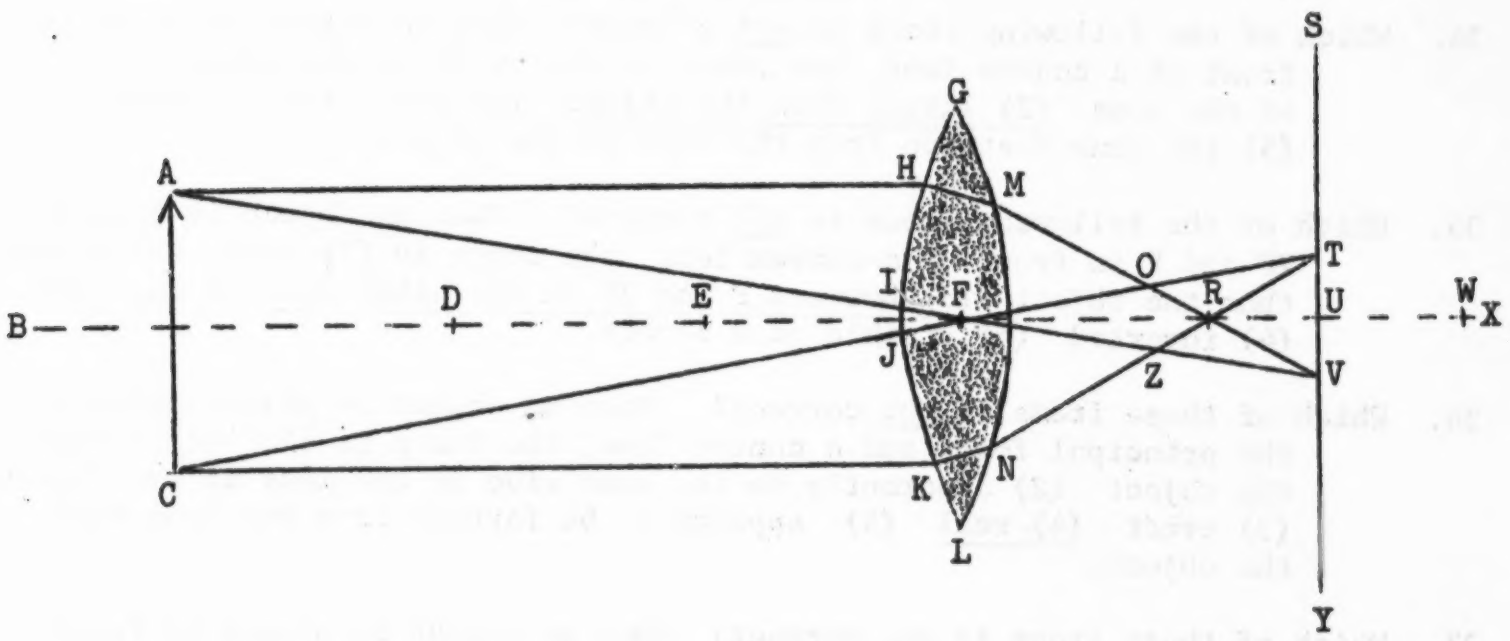
DIRECTIONS: Drawings J and K show glass lenses, surrounded by air. "I" indicates incident rays. By letter, select the path that the ray will take after refraction.

17. In drawing J, the path is (1) A (2) B (3) C (4) D.

18. In drawing K, the path is (1) A (2) B (3) C (4) D.

19. In drawing J, the lens is (1) double concave (2) double convex (3) convex-concave (4) plane-concave.

20. In drawing K, the lens is (1) concave-convex (2) plane-convex (3) double - convex (4) double-concave (5) concave-convex.



DIRECTIONS: AC is a luminous object in front of a lens. FR equals RW. DE equals EF. Questions 21 to 30 refer to the above diagram.

21. Where is the principal focus? (1) T (2) R (3) U (4) F (5) W.

22. Where is the optical center? (1) from B to X (2) F (3) R (4) from G to L (5) from S to Y.

23. Where is the principal axis? (1) SY (2) CK (3) R (4) GL (5) BX.

24. Indicate the image. (1) MN (2) FR (3) OR (4) TV (5) SY.

25. Describe the image. (1) real (2) virtual (3) There is no image.

26. Locate a secondary axis. (1) BX (2) MV (3) CK (4) HM (5) AV.

27. The image is larger than the object. (1) true (2) false.

28. The image is (1) erect (2) inverted (3) missing.

29. The image distance is (1) equal to the object distance (2) larger than the object distance (3) less than the object distance.

30. Indicate the principal focal length. (1) DF (2) TV (3) FU (4) FR (5) NR.

MULTIPLE CHOICE

31. The change in direction of a light ray upon entering obliquely another medium of different density is called (1) reflection (2) polarization (3) refraction (4) acceleration (5) absorption.

32. The ratio of the speed of light in air to its speed in another substance is called what? (1) index of acceleration (2) index of reflection (3) angle of maximum polarization (4) index of refraction (5) critical angle.

33. In which of these substances does light travel the slowest? (1) alcohol (2) diamond (3) water (4) crown glass (5) olive oil.

34. Which of the following items is not correct? When an object is at 2F in front of a convex lens, the image is (1) at 2F on the other side of the lens (2) larger than the object (3) real (4) inverted (5) the same distance from the lens as the object.

35. Which of the following items is not correct? When an object is between 2F and F in front of a convex lens, the image is (1) real (2) larger than the object (3) between F and 2F on the other side of the lens (4) inverted (5) visible on a screen.

36. Which of these items is not correct? When an object is placed between the principal focus and a convex lens, the image is (1) larger than the object (2) apparently on the same side of the lens as the object (3) erect (4) real (5) appears to be farther from the lens than the object.

37. Which of these items is not correct? When an object is placed in front of a concave lens, the image is (1) erect (2) larger than the object (3) virtual (4) apparently on the same side of the lens as the object (5) apparently between the lens and the object.

38. Which of these items is not a part of the eye? (1) cornea (2) retina (3) lens (4) shutter (5) Iris.

39. In which eye defect is a concave lens used for correction? (1) astigmatism (2) farsightedness (3) nearsightedness.

40. At about how many inches from the eye do most people see most distinctly? (1) 25 (2) 100 (3) 6 (4) 2 (5) 10.

PROBLEMS

41. The speed of light through an opal is 128,000 miles per second. What is its index of refraction? (1) 2.47 (2) 1.62 (3) 1.52 (4) 1.36 (5) 1.45.

42. An object is placed 14 inches from a convex lens with a 6-in. focal length. How many inches from the lens will the image be formed? (1) 2.1 (2) 10.5 (3) 20 (4) 0.05 (5) 20.5.

43. A microscope tube is 15 cm. long. What is the magnifying power when the eyepiece has a focal length of 2.5 cm., and the objective has a focal length of 0.4 cm.? (1) 62.5 (2) 375 (3) 10 (4) 37.5 (5) 3.75.

44. A standard lantern slide bears a picture 2½ in. square. Find the focal length in inches of the lens needed to produce an image 6 ft. by 6 ft., at a distance of 40 ft. in front of the lens. (1) 10 (2) 12 (3) 14 (4) 16 (5) 18.

PHYSICS: GENERAL

TEXT - REFERENCES - MATERIALS

Modern Physics by Dull, Metcalfe and Brooks. Henry Holt and Company

1. Science Digest, 201 East Ontario St., Chicago, Illinois
2. Scientific American, 415 Madison Ave., New York 17, N. Y
3. Science News Letter, 1719 N. Street, Washington 6, D. C.
4. Current Science and Aviation, 1250 Fairwood Ave., Columbus 16, O.

PROFESSIONAL AIDS

Magazines

1. The Science Teacher, Journal of the National Science Teachers Association, 1201 Sixteenth St., N. W., Washington 6, D. C.
2. Science Education, official organ of the National Association in Science Teaching, 49 Sheridan Ave., Albany 10, N. Y.
3. School Science and Mathematics, Box 408, Oak Park, Illinois
4. Physics Today, 335 East 45th St., New York 17, N. Y.

Name _____ Sheet No. ___ Hour___ Ch. No.___ Score ____

Last name first

	T	F					T	F					T	F			
1.	(1)	(2)	(3)	(4)	(5)	31.	(1)	(2)	(3)	(4)	(5)	61.	(1)	(2)	(3)	(4)	(5)
2.	(1)	(2)	(3)	(4)	(5)	32.	(1)	(2)	(3)	(4)	(5)	62.	(1)	)2)	(3)	(4)	(5)
3.	(1)	(2)	(3)	(4)	(5)	33.	(1)	(2)	(3)	(4)	(5)	63.	(1)	(2)	(3)	(4)	(5)
4.	(1)	(2)	(3)	(4)	(5)	34.	(1)	(2)	(3)	(4)	(5)	64.	(1)	(2)	(3)	(4)	(5)
5.	(1)	(2)	(3)	(4)	(5)	35.	(1)	(2)	(3)	(4)	(5)	65.	(1)	(2)	(3)	(4)	(5)
6.	(1)	(2)	(3)	(4)	(5)	36.	(1)	(2)	(3)	(4)	(5)	66.	(1)	(2)	(3)	(4)	(5)
7.	(1)	(2)	(3)	(4)	(5)	37.	(1)	(2)	(3)	(4)	(5)	67.	(1)	(2)	(3)	(4)	(5)
8.	(1)	(2)	(3)	(4)	(5)	38.	(1)	(2)	(3)	(4)	(5)	68.	(1)	(2)	(3)	(4)	(5)
9.	(1)	(2)	(3)	(4)	(5)	39.	(1)	(2)	(3)	(4)	(5)	69.	(1)	(2)	(3)	(4)	(5)
10.	(1)	(2)	(3)	(4)	(5)	40.	(1)	(2)	(3)	(4)	(5)	70.	(1)	(2)	(3)	(4)	(5)
11.	(1)	(2)	(3)	(4)	(5)	41.	(1)	(2)	(3)	(4)	(5)	71.	(1)	(2)	(3)	(4)	(5)
12.	(1)	(2)	(3)	(4)	(5)	42.	(1)	(2)	(3)	(4)	(5)	72.	(1)	(2)	(3)	(4)	(5)
13.	(1)	(2)	(3)	(4)	(5)	43.	(1)	(2)	(3)	(4)	(5)	73.	(1)	(2)	(3)	(4)	(5)
14.	(1)	(2)	(3)	(4)	(5)	44.	(1)	(2)	(3)	(4)	(5)	74.	(1)	(2)	(3)	(4)	(5)
15.	(1)	(2)	(3)	(4)	(5)	45.	(1)	(2)	(3)	(4)	(5)	75.	(1)	(2)	(3)	(4)	(5)
16.	(1)	(2)	(3)	(4)	(5)	46.	(1)	(2)	(3)	(4)	(5)	76.	(1)	(2)	(3)	(4)	(5)
17.	(1)	(2)	(3)	(4)	(5)	47.	(1)	(2)	(3)	(4)	(5)	77.	(1)	(2)	(3)	(4)	(5)
18.	(1)	(2)	(3)	(4)	(5)	48.	(1)	(2)	(3)	(4)	(5)	78.	(1)	(2)	(3)	(4)	(5)
19.	(1)	(2)	(3)	(4)	(5)	49.	(1)	(2)	(3)	(4)	(5)	79.	(1)	(2)	(3)	(4)	(5)
20.	(1)	(2)	(3)	(4)	(5)	50.	(1)	(2)	(3)	(4)	(5)	80.	(1)	(2)	(3)	(4)	(5)
21.	(1)	(2)	(3)	(4)	(5)	51.	(1)	(2)	(3)	(4)	(5)	81.	(1)	(2)	(3)	(4)	(5)
22.	(1)	(2)	(3)	(4)	(5)	52.	(1)	(2)	(3)	(4)	(5)	82.	(1)	(2)	(3)	(4)	(5)
23.	(1)	(2)	(3)	(4)	(5)	53.	(1)	(2)	(3)	(4)	(5)	83.	(1)	(2)	(3)	(4)	(5)
24.	(1)	(2)	(3)	(4)	(5)	54.	(1)	(2)	(3)	(4)	(5)	84.	(1)	(2)	(3)	(4)	(5)
25.	(1)	(2)	(3)	(4)	(5)	55.	(1)	(2)	(3)	(4)	(5)	85.	(1)	(2)	(3)	(40	(5)
26.	(1)	(2)	(3)	(4)	(5)	56.	(1)	(2)	(3)	(4)	(5)	86.	(1)	(2)	(3)	(4)	(5)
27.	(1)	(2)	(3)	(4)	(5)	57.	(1)	(2)	(3)	(4)	(5)	87.	(1)	(2)	(3)	(4)	(5)
28.	(1)	(2)	(3)	(4)	(5)	58.	(1)	(2)	(3)	(4)	(5)	88.	(1)	(2)	(3)	(4)	(5)
29.	(1)	(2)	(3)	(4)	(5)	59.	(1)	(2)	(3)	(4)	(5)	89.	(1)	(2)	(3)	(4)	(5)
30.	(1)	(2)	(3)	(4)	(5)	60.	(1)	(2)	(3)	(4)	(5)	90.	(1)	(2)	(3)	(4)	(5)

PHYSICS: ADVANCED PLACEMENT

(College Level)

OVERVIEW

The idea that curricula should be adjusted to the needs, interests, and abilities of students is not new. Teachers have striven to do this, but, too often, wide differences in ability within the class, inadequate equipment and supplies, large classes, crowded school buildings and heavy extra-curricular duties have contributed to the partial failure to meet the needs of those who are capable of doing more work and more advanced work. This Advanced Placement Physics curriculum outline is designed as an aid in raising the achievement level of the high school senior.

It would be safe to say that this outline cannot be entirely covered in one school year. It is more important that students be able to apply physical concepts to new situations. The unit on mechanics should be thoroughly covered since it is needed in all areas of physics. When the preparation in mathematics will permit it, the calculus should be used, since it makes possible the development of principles and concepts more efficiently and more precisely. A thorough grasp of trigonometry should be a requirement.

SELECTION OF STUDENTS - Will be Based on the Following:

I. Mathematical preparation.

II. Intelligence quotient.

III. School grades.

IV. Ability in English

V. Counselor's recommendation.

VI. Principal's recommendation.

VII. Student's wishes.

VIII. Parent's wishes.

IX. Teacher's recommendation.

X. Grade made in standard general physics course.

XI. Class size: Ideally the class size at the beginning of the first semester should be no larger than twenty.

OBJECTIVES

A. General - An advanced secondary school course in physics should aim at developing the student's abilities in many areas. The student receiving college credit for advanced placement should be able:

1. To demonstrate a clear understanding of important physical concepts and principles, together with their limitations.

2. To select the physical principles which are applicable to a given situation.

3. To read, understand, and interpret physical information, verbal and mathematical.

4. To use elementary mathematical reasoning - arithmetical, algebraic, geometric, and trigonometric - in a physical or problem situation.

5. To explain in his own words the steps and line of reasoning used in solving a particular problem:

   a. define the scientific terms and concepts used
   b. state the principles being applied
   c. explain the successive steps
   d. interpret any results or conclusions

6. To recognize the reasons for the acceptance or "truth" of statements, whether by definitions, by logical deductions from adapted laws or principles, or by generalization from experimental observations.

B. Specific

Unit I. Mechanics

A strong foundation in mechanics is necessary for a real understanding of other phases of physics, and once the concepts of mechanics are grasped, other fields can be approached more efficiently. Rotation and simple harmonic motions will also be studied in this unit, and an excellent opportunity for reviewing systems of units, renewing concepts using methods of calculus, and practicing derivation of formulas will be offered. Extensive problem sets should be assigned to students.

Unit II. Heat

The heat unit has a very close relationsip to nuclear and solar energy, and we need to be very much concerned with the development of these modern energy resources. Emphasis should be placed upon measuring the heat content of an object in terms of mechanical-energy units. Since thermal effects occur with, and are ultimately related to, mechanical effects, the First and Second Laws of Thermodynamics will also be studied in this unit. Extensive problem sets should be assigned to students.

Unit III. The concepts of wave motion in sound overlaps other areas of physics, and should be given special emphasis in this unit. The mathematics implication will offer a challenge and extensive problem sets should be assigned to students.

Unit IV. Electricity and Magnetism

The interrelation of electricity and magnetism to electronics and nucleonics will offer a stimulating challenge to the students in studying this unit. The following topics will also be offered: Potential, dielectric co-efficient and permittivity, thermoelectricity, Thermocouple equation, Avogardro's number, magnetic field, and control of the ion's path in the cyclotron, and Planck's light quanta or photon in relation to the photoelectric effect. A review of units with an assignment of problem sets will be expected in this unit.

Unit V. Optics

A well-prepared background in optical spectra is necessary in order to study Atomic Physics. Diffraction and polarisation should be studied extensively in this unit. Demonstrations with appropriate experiments and extensive problem sets should be assigned to the students.

Unit VI. Atomic Physics

This unit includes materials that show how we can study the nature and behavior of particles still smaller than the molecule and atom. Studies in this area, like those in other areas of science, have had a profound influence on science and the social and political structure of today's world. Most of this unit will be by lectures and demonstrations, with an assignment of problem sets for the student.

METHODS, PROCEDURES AND TENCHIQUES

An advanced course in physics should be approached with the idea of covering basic concepts of the major areas. The student need not assume that every detail of the area is to be studied. Any attempt to do so would result in only a superficial acquaintance with many topics and no mastery of fundamentals. Mechanics is clearly the most important area of a beginning course in physics, for many of the concepts and relations developed there carry over into other areas and here a particular aim should be the development of maturity and understanding. The same effort to grasp fundamentals should be carried over into the other areas studied. A student should do enough work in mechanics to be thoroughly grounded in Newton's laws, the conservation principles, and the consequences of those principles.

A student should be able to handle applications which use algebra, trigonometry, and calculus. The student should make as full use as possible of the richness afforded by the calculus concepts, and should not be satisfied merely with calculus manipulations. He should be able to make calculations on a slide rule.

Particular emphasis should be placed on measuring units, either British or Metric system The student should be able to understand and use the vocabulary of physics for the entire course.

Emphasis must be given to the laboratory side of instruction. In order to derive maximum benefit from laboratory experience, the student should do far more than follow a set of detailed instructions in perfunctory fashion. Though much of his work will be based upon deductively derived relations, he should have some opportunity to see how generalizations are arrived at inductively from empirical observations. His instruction should emphasize an increased level of difficulty, more detailed analysis, precision in measurements, consideration of "significant figures," and the use of more complex graphs.

Serious independent research by the student should be emphasized.. Demonstrations by both students and instructor should be given throughout the course.

This is only a suggested plan and is subject to changes at the discretion of the instructor as the course is being taught.

OUTLINE OF SCIENCE

Unit I. Mechanics

A. Composition and Resolution Vectors

1. Units and standards
2. Force
3. Graphical representation of forces

a. Scalar quantities
b. Vector quantities

4. Components of vectors
5. Resultant or vector sum

a. Coplanar forces
b. Concurrent forces

(1) Parallelogram method
(2) Triangle method

6. Vector Difference

B. Equilibrium

1. Equilibrium - Newton's First Law

a. Translational motion
b. Rotational motion
c. Conditions for equilibrium
d. Equilibrium

(1) Stable
(2) Unstable
(3) Neutral

2. Newton's Third Law of Motion

3. Friction

a. Viscosity
b. Rolling friction
c. Force of static friction
d. Coefficient of friction

(1) Static friction
(2) Kinetic

C. Equilibrium - Moment of Force

1. Conditions for equilibrium

a. Fir t
b. Second

2. Center of Gravity
3. Couples

D. Rectilinear Motion - Kinematics

1. Velocities

a. Average
b. Instantaneous

2. Accelerations

a. Average
b. Instantaneous
c. Constant

3. Ve city and coordinate by integration
4. Freely falling bodies
5. Velocity components - relative velocity

E. Newton's Second Law - Gravitation

1. Mass
2. Systems of Units
3. Mass and Weight
4. Newton's Law of Universal Gravitation
5. The Mass of the Earth
6. Variations in the acceleration due to gravity
7. Applications of Newton's Second Law

F. Motion in a Place

1. Motion of a projectile
2. Circular motion
3. Centripetal Force
4. Motion in a vertical circle
5. Tangential acceleration

G. Work and Energy

1. Work done when force is variable
2. Gravitational potential energy
3. Absolute Values of potential and kinetic energy
4. Elastic potential energy
5. Work and Energy - Conservation of mechanical energy
6. Conservative and dissipative forces
7. Power - Unit Definitions

    a. Horsepower
    b. Kilowatt-hour

8. Mechanical advantage

    a. Actual
    b. Ideal

9. Mass and Energy

H. Impulse and Momentum

1. Conservation of momentum
2. Elastic and inelastic collisions
3. Principles of jet propulsion
4. Newton's Second Law

I. Rotation

1. Angular velocity
2. Angular acceleration
3. Rotation with constant angular acceleration
4. Relation between angular and linear velocity and acceleration
5. Kinetic energy of rotation - Moment of Inertia
6. Work and Power in rotational motion
7. Torque and angular acceleration
8. Angular momentum
9. Rotation about a moving axis - Precession

    a. Top
    b. Gyroscope

J. Elasticity

1. Stress

    a. Tensile
    b. Shearing
    c. Tangential
    d. Compression
    e. Hydrostatic Pressure

2. Strain

   a. Tensile
   b. Compressive
   c. Shearing
   d. Volume

3. Elastic Modulus - Hooke's Law
4. Modulus

   a. Stretch or Young's
   b. Shear
   c. Rigidity
   d. Torsion

5. Elastic limit of proportional limit
6. Force constant or stiffness

K. Harmonic Motion

1. Elastic restoring forces

   a. Definitions

      (1) Simple harmonic motion
      (2) Periodic
      (3) Oscillatory
      (4) Complete vibration or oscillation
      (5) Period
      (6) Frequency
      (7) Coordinate
      (8) Amplitude

2. Equations of simple harmonic motion

   a. Reference point
   b. Reference circle

3. The simple pendulum
4. Angular harmonic motion
5. Physical pendulum
6. Center of oscillation - center of percussion

L. Hydrostatics

1. Pressure in fluid
2. The hydrostatic paradox
3. Pressure gauges

   a. Open-tube Monometer
   b. Barometer

4. Archimedes' Principle
5. Forces against a dam

M. Surface Tension

1. Pressure difference across a surface film
2. Minimal Surfaces
3. Capillarity

    a. Adhesive force
    b. Cohesive force
    c. Contact angle

4. Wetting agents or detergents

N. Hydrodynamics and viscosity

1. Streamline flow
2. Turbulent flow
3. Bernoulli's equation

    a. Absolute pressure
    b. Pressure head
    c. Velocity head
    d. Elevation head

4. The Equation of Continuity
5. Applications of Bernoulli's Equation

    a. Equations of hydrostatics
    b. Torricelli's Theorem
    c. The Venturi Meter
    d. The Pitot tube
    e. The curved flight of a spinning ball
    f. Lift on an aircraft wing
    g. Viscosity
    h. Laminar and turbulent flow
    i. Reynolds' Number
    j. Flow of a viscous fluid through a pipe
    k. Stoke's Law

Unit II. Heat

A. Temperature - Expansion

1. Thermometers
2. Temperature scales

    a. Fahrenheit
    b. Centigrade
    c. Kelvin
    d. Fixed Points
    e. Lowest temperatures
    f. High temperatures

3. Resistance thermometers
4. Thermocouple
5. Optical pyrometer

6. Constant volume gas thermometers
7. Linear expansion
8. Bimetallic elements
9. Surface and volume expansion
10. Thermal stresses

B. Quantity of Heat

1. Heat, a form of energy
2. Units of Heat

    a. Gram calorie
    b. Kilogram calorie
    c. Btu.

3. Internal energy
4. The Mechanical equivalent of heat
5. Heat capacity - specific heat
6. Calorimetry
7. Heat of combustion
8. Change of phase

    a. Solid to liquid
    b. Liquid to gas

9. Definitions

    a. Normal boiling point
    b. Heat of fusion
    c. Heat of vaporization
    d. Heat of condensation
    e. Heat of solidification

10. Measurements of heats of fusion and vaporization
11. Effect of dissolved substances on freezing and boiling points

C. Transfer of heat

1. Temperature gradient
2. Heat through a cylindrical pipe cover
3. Convection

    a. Forced
    b. Free

4. Radiation
5. Stefan's Law
6. The ideal radiator
7. The ideally black surface

D. The First Law of Thermodynamics

1. External work
2. Internal work

3. Work in changing the volume
4. Work depending on path
5. Work and heat
6. The First Law of Thermodynamics
7. Adiabatic process
8. Isovolumetric process
9. Isobaric process
10. Free expansion
11. Throttling process
12. Differential form of the First Law

E. Thermal propertines of solids, liquids and gases

1. Boyle's Law
2. Gay-Lussac's Law
3. The Equation of state of an ideal gas
4. Molecular theory of matter
5. Kinetic theory of an ideal gas
6. Specific heats of an ideal gas
7. Adiabatic compression or expansion of an ideal gas
8. Liquefaction of gases

    a. Vapor pressure
    b. Saturated vapor
    c. Vapor pressure curve

9. Effect of pressure on boiling and freezing points - Regelation
10. The triple point
11. Humidity

    a. Absolute
    b. Relative
    c. Dalton's Law

12. Thermodynamic surfaces

F. The Second Law of Thermodynamics

1. Thermal efficiency
2. Internal combustion engine
3. Diesel engine
4. Steam engine
5. Second Law of Thermodynamics
6. The refrigerator
7. The Carnot Cycle
8. The Kelvin temperature scale
9. Absolute Zero

Unit III. Sound

A. Wave Motion

1. Propagation of a Disturbance in a medium

    a. Definite speed of displacement propagation

b. Transverse pulse
c. Longitudinal pulse

2. Calculation of Speed of a transverse pulse
3. Calculation of speed of a longitudinal pulse

a. Longitudinal momentum
b. Longitudinal impulse
c. Impulse - Momentum Theorem

4. The motion of a wave

a. Condensation
b. Rarefaction

5. Adiabatic character of a longitudinal wave
6. Mathematical representation of a wave

B. Vibrating Bodies

1. Stationary waves on a string
2. Principle of superposition - Interference

a. Nodes
b. Antinodes

3. Vibration of a string fixes at both ends

a. Fundamental frequency
b. Overtones
c. Harmonics

4. Demonstration of the harmonic series in a vibrating string
5. Resonance
6. Interference of longitudinal waves
7. Stationary longitudinal waves
8. Vibrations of organ pipes

a. Open pipes
b. Closed pipes

9. Vibrations of rods and plates

C. Acoustical Phenomena

1. Pressure variations in a sound wave
2. Intensity
3. Intensity level and loudness
4. The Ear and hearing
5. Quality and pitch
6. Beats
7. Combination tones

a. Consonance
b. Dissonance

c. Difference tone
d. Summation tone

8. The Doppler Effect
9. Musical intervals and scales

a. Octave
b. Major triad
c. Major diatonic scale
d. Equally tempered scale

Unit IV. Electricity and Magnetism

A. Coulomb's Law

1. Electric charges

a. Negative
b. Positive

2. Atomic structure

a. Electron
b. Nucleus

(1) Proton
(2) Neutron

c. Atomic Number

3. Charging by contact
4. Conductors and insulators
5. Charging a metal by induction
6. Coulomb's Law
7. Rutherford's nuclear atom
8. Systems of Units

a. Electrostatic
b. Electromagnetic
c. Practical system

B. The Electric Field

1. Introduction

a. Definition
b. Direction determination

2. Calculation of electric intensity
3. Lines of force

a. Definition
b. Mapping

4. Gauss' Law - Conclusions

a. Concerning the charge within a conductor
b. Concerning the field outside a charged conductor

(1) Sphere
(2) Between opositely charged parallel plates

5. The Millikan oil-drop experiment
6. Dielectric strength

C. Potential

1. Electrical potential energy
2. Potential

a. First definition of the volt
b. Second definition of the volt

3. Potential difference
4. Potential of a charged spherical conductor
5. The energy principle
6. Equipotential surfaces
7. Potential gradient
8. Sharing of charge by conductors
9. The Van de Graaff generator

D. Capacitance - Properties of Dielectrics

1. Capacitors
2. The parallel plate capacitor
3. Capacitors in series and parallel
4. Energy of a charged capacitor
5. Dielectric coefficient - permittivity
6. Induced charges on a dielectric
7. Molecular theory of induced charges on a dielectric

E. Current and Resistance

1. Current
2. The Complete Circuit

a. Internal
b. External

3. Resistivity, resistance, and Ohm's Law
4. Standard resistors
5. Calculation of resistance
6. Measurement of current, potential difference and resistance
7. The Wheatstone Bridge
8. Joule's Law

F. DC Circuits

1. Electromotive force

2. The circuit equation
3. Potential difference between points in a circuit
4. Terminal voltage of a seat of emf.
5. The Potentiometer
6. Series and parallel connection of resistors
7. Networks containing seats of emf.
8. Kirchoff's Rules
9. Power
10. Measurement of power and energy
11. Graphical methods

G. Electrochemistry and Thermoelectricity

1. Electrolysis
2. Mechanism of electrolytic conduction
3. The determination of Avogadro's Number
4. The electrolysis of water

    a. Thermal dissociation
    b. Electrolytic dissociation

5. Electrode potentials
6. Electrolytic refining of metals
7. Galvanic cells
8. The Daniell cell
9. Polarization
10. The dry cell
11. The lead storage battery
12. Standard cells
13. Applications of the fundamental thermocouple equation

H. The Magnetic Field

1. Magnetism
2. The Magnetic Field - induction
3. Lines of induction - magnetic flux
4. Orbits of charged particles in magnetic fields
5. The Cyclotron
6. Measurement of e/m
7. The mass spectrograph
8. Force on a current-carrying conductor
9. Force and torque on a complete circuit

    a. Rectangular loop
    b. Circular loop
    c. Solenoid

I. Galvanometers, Ammeters, and Voltmeters - the DC Motor

1. The Galvanometer

    a. Current sensitivity
    b. Null instruments

2. The pivoted coil galvanometer

3. Ammeters and voltmeters
4. The ballistic galvanometer
5. The Dynamometer
6. The Direct-current motor

    a. Series
    b. Shunt
    c. Compound

J. Magnetic field of a current and of a moving charge

1. Magnetic field of a current element
2. Magnetic field of a long straight conductor
3. Force between parallel conductors - the ampere

    a. Definition
    b. Current balance

4. Magnetic field of a circular turn
5. Ampere's Law
6. Field of a solenoid and of a toroid

K. Induced electromotive force

1. Motional electromotive force
2. The Faraday Law
3. Lenz's Law
4. The betatron
5. Induced emf in a rotating coil
6. The direct current generator
7. Search coil method of measuring magnetic flux
8. Galvanometer damping
9. Eddy currents

L. Magnetic properties of matter

1. Magnetic properties of matter

    a. Paramagnetic
    b. Diamagnetic

2. Magnetic permeability
3. Magnetic intensity
4. Ferromagnetism
5. The Curie temperature
6. Hysteresis

    a. Hysteresis loop
    b. Retentivity or remanence
    c. Coercivity

7. Ampere's theory of magnetism
8. Magnetic comains
9. Magnetic poles
10. Torque on a bar magnet

11. Force between magnetic poles
12. Oscillation of a bar magnet in a magnetic field
13. The magnetic field of the earth

    a. Angle of inclination
    b. Declination

14. The Magnetic circuit

M. Inductance and Capacitance

1. Self-Inductance
2. Circuit containing inductance and resistance
3. Energy associated with an inductor
4. The induction coil
5. Circuit containing capacitance and resistance
6. The "sweep" circuit
7. Electrical oscillations
8. Propagation of a disturbance along a transmission line

N. Alternating Currents and Electromagnetic Waves

1. The alternating current series circuit
2. Effective values
3. Phase relations between voltage and current
4. Potential difference between points of an AC circuit
5. Resonance
6. Power in AC circuits
7. The transformer
8. Electromagnetic waves
9. The propagation of energy by an electromagnetic wave
10. Radiation of electromagnetic waves

    a. Oscillating dipole
    b. Wave front

O. Electronics

1. Vacuum pumps
2. Thermionic emission
3. Rectification

    a. Half-wave
    b. Full-wave

4. The triode
5. Vacuum tube relay
6. Elementary principles of amplification
7. Elementary principles of oscillation
8. Amplitude modulation
9. Demodulation or detection
10. The radio receiver
11. The cathode-ray tube
12. The photoelectric effect

    a. Threshold frequency
    b. Light quanta or photons

13. The X-ray tube
14. Conduction in gases

    a. Ionizing agent
    b. Glow discharge
    c. Cathode layer
    d. Crookes' Dark Space
    e. Negative glow
    f. Faraday's Dark Space
    g. Striations

Unit V. Light

A. The nature and propagation of light

1. The nature of light
2. Waves and rays
3. Shadows

    a. Umbra
    b. Penumbra

4. The velocity of light

    a. Roemer's method
    b. Fizeau's method
    c. Michelson's method

5. Index of refraction
6. Huygens' Principle
7. Atmospheric refraction

B. Reflection and refraction at plane surfaces

1. Reflection of a plane wave at a plane surface

    a. Angle of incidence
    b. Angle of reflection

2. Refraction of a plane wave at a plane surface

    a. Angle of incidence
    b. Angle of refraction
    c. Snell's Law

3. Ray treatment of reflection and refraction
4. Total internal reflection - critical angle
5. Refraction by a plane parallel plate
6. Refraction by a prism

    a. Deviation
    b. Dispersion
    c. Angle of deviation
    d. Minimum deviation

7. Dispersion

    a. Direct-vision prism
    b. Achromatic prism

C. Reflection and refraction at a single surface

1. Reflection at a plane mirror - image description
2. Reflection at a spherical mirror

    a. Image descriptions
    b. Aberration

3. Sign conventions
4. Focal point and focal length
5. Graphical methods
6. Refraction at a plane surface
7. Refraction at a spherical surface
8. Reflection as a special case of refraction

D. Lenses and lens aberrations

1. Images as objects - the virtual object
2. The thin lens

    a. The lensmaker's equation
    b. The Gaussian form of the thin lens equation

3. The Newtonian form of the thin equation
4. Diverging lenses
5. Cylindrical lenses
6. Graphic methods of locating image
7. Images as objects
8. Lens aberrations

    a. Chromatic
    b. Monochromatic
    c. Spherical
    d. Coma
    e. Astigmatism and field of curvature

E. Optical instruments

1. The eye
2. Defects of vision

    a. Emmetropic
    b. Ametropic

        (1) Myopia
        (2) Hyperopia

    c. Astigmatism
    d. Presbyopia

3. Optometrists terms

    a. Power
    b. Diopter

4. The Simple microscope or magnifier

    a. Angular magnification
    b. Lateral magnification
    c. Ocular or eyepiece

5. The compound microscope
6. Telescopes

    a. Astronomical
    b. Terrestrial
    c. Prism binocular
    d. Galilean

7. The camera
8. The projection lantern
9. The prism spectrometer

    a. Spectra

        (1) Continuous
        (2) Line

F. Illumination

1. Sources of light

    a. Carbon arc
    b. Monochromatic
    c. Fluorescence

2. Luminous Flux

    a. Radiant power
    b. Visual sensation

        (1) Hue
        (2) Saturation
        (3) Brightness

3. The standard source and the lumen
4. Illuminance
5. Luminous intensity of a point source
6. Illuminance produced by a point source
7. Photometry
8. Extended sources - luminance

G. Color

1. Colorimetry
2. Additive color mixture

3. Color mixture data for spectrum colors
4. The chromaticity diagram
5. Spectrophotometry
6. Dominant wavelength and purity
7. The subtractive method of color mixing
8. Subtractive "Primaries"

H. Interference and diffraction

1. Principles of interference - coherent sources

   a. Geometric optics
   b. Physical optics
   c. Principle of superposition
   d. Coherent sources
   e. Interference frings

2. Young's experiment and Pohl's experiment
3. Phase changes in reflection
4. Interference in thin films
5. Newton's rings
6. Diffraction
7. Fraunhofer diffraction by a single slit
8. The plane diffraction grating

   a. First order spectrum
   b. Second order spectrum

9. Fresnel diffraction due to a circular obstacle
10. Diffraction of X-rays by a crystal
11. The resolving power of optical instruments

    a. Resolving power
    b. Limit of resolution

12. The electron microscope

I. Polarization

1. Polarization
2. Polarization by reflection

   a. Polarizing angle
   b. Brewster's Law

3. Double refraction

   a. Anisotropic crystals
   b. Birefringent crystals
   c. Ordinary ray
   d. Extra-ordinary ray
   e. Uniaxial crystals
   f. Biaxial crystals

4. Polarization by double refraction - Dichroism
5. Percentage polarization - Malus' law

6. The scattering of light
7. Circular and elliptic polarization

    a. Circularly polarized light
    b. Quarter-wave plate
    c. Half-wave plate
    d. Elliptically polarized light

8. Production of colors by polarized light
9. Optical stress analysis

    a. Photoelasticity
    b. Kerr effect

10. Study of crystals by convergent polarized light
11. Optical activity - rotation of the plane of polarization

Unit VI. Atomic physics

A. Spectra and atomic physics

1. Line spectra
2. Spectral series

    a. Balmer series
    b. Rydberg constant
    c. Lyman series
    d. Paschen series
    e. Brackett series

3. The Bohr atom

    a. First postulate
    b. Second postulate
    c. Normal state atom
    d. Excited state atom

4. Deuterium
5. Wave mechanics or quantum mechanics
6. Absorption spectra

    a. Resonance radiation
    b. Fraunhofer lines

7. Band spectra
8. X-ray spectra

    a. Atomic number
    b. Inverse photoelectric effect

B. Radioactivity and nuclear physics

1. Natural radioactivity
2. Alpha-particles
3. Beta-particles

4. Gamma rays
5. Radioactive transformations

   a. The atomic number Z
   b. The atomic mass
   c. The mass number A
   d. Half-life

6. Artificial nuclear disintigration
7. Cosmic rays - The positron and meson
8. The neutron
9. Nuclear fission

   a. Atomic pile or nuclear reactor - controlled fission
   b. Atomic bomb - uncontrolled fission

10. Thermonuclear reactions - the proton-proton chain

C. Suggested student experiments

1. Radiation detection
2. Radiation measurement

D. Suggested vocabulary

Neutrino decay half-life
thermonuclear

TESTING AND EVALUATION

Advanced Placement Physics tests should show whether the student has acquired the ability to comprehend the subject matter thoroughly. This ability is needed for problem solving, particularly if the problems require more than the manipulation of numbers into formulas. About 25% of the test should contain problems in which calculus can be used in solving problems. Some of the questions can be answered objectively, while others will require a definite organized solution or explanation. A choice of questions should be available to the students. Some samples of the types of questions are:

Multiple Choice - Directions: Put the letter that refers to the correct statement to the right of each question. There may be more than one correct choice or no correct choice to each question.

Examples:

1. In the MKS system one can measure energy directly in (a) erg, (b) joule, (c) Kg, (d) MKg, (e) ft-lb, (f) none of these.

2. Which of the following quantities are vector quantities? (a) Kinetic energy, (b) momentum, (c) mass, (d) time, (e) velocity, (f) force, (g) power.

3. The average force may be measured by: (a) work done multiplied by distance moved, (b) mass multiplied by acceleration, (c) power delivered divided by the velocity of an object, (d) momentum change divided by the elapsed time.

4. By the concept of Mass we describe and often measure the property of objects as: (a) occupying a certain amount of space, (b) requiring a force to be set in motion, (c) exerting gravitational forces on other objects.

5. Two equal forces act on objects of different mass. If they act for the same length of time, the two masses will? (a) acquire the same speed, (b) acquire momenta of equal magnitude, (c) acquire equal amounts of kinetic energy, (d) acquire motion not correctly described by A, B, or C.

6. The concept of wave properties for particles applies: (a) only to particles without rest mass, (b) only to electrons, (c) to photons and electons only, (d) to all particles.

Completion

7. Fill in the table with choices from the following list: mile, slug, meter, ft, ft-lb, pound-mass, erg, dyhe, joule, ton, Newton, Kilogram

	Length	Mass	Force	Energy
MKS				
Engl. Absolute				
Engl. Engineering (Gravitational)				

Essay

8. Briefly, in a few paragraphs, discuss the Doppler effect, involving a moving source, moving observer, and moving transmitting medium. first in the case of sound, and then in the case of light as used in astronomy.

9. Discuss energy transmission by various kinds of wave motions.

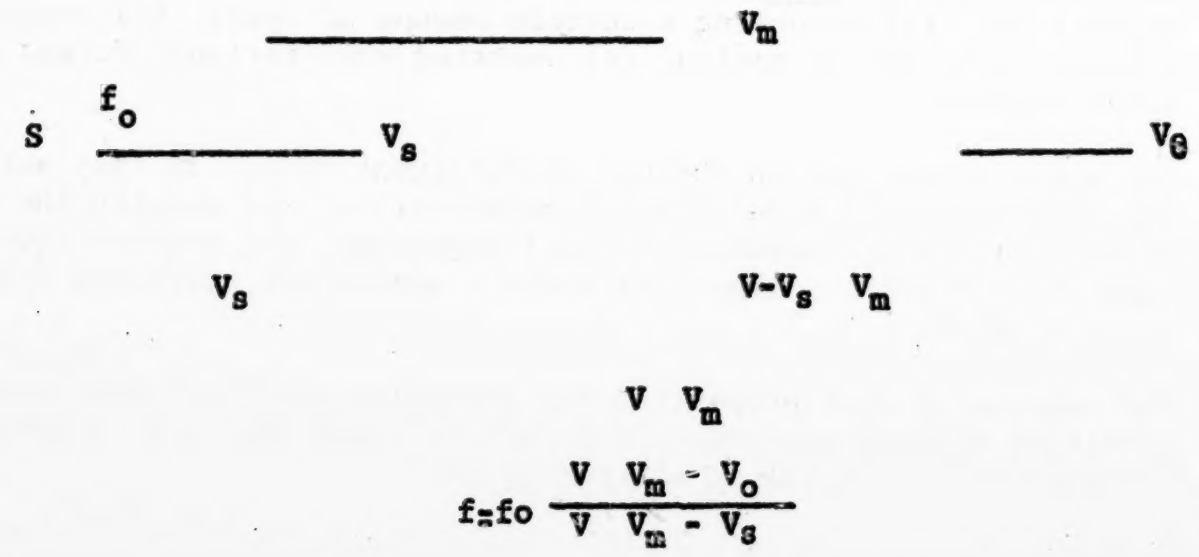
Problem Solving

10. Ripples having a wave length of 0.330 cm and are excited electrically on the water surface by electrostatic forces from an alternating current of 60 cycles/sec. One ripple is produced at each half cycle or every 1/120 sec. Find the surface tension.

    Solve this problem using calculus. Find the wave length having the minimum velocity in water by setting dv/d = 0 or

11. Calculate the velocity of sound in air at 0°C, if the density of air is 1.29 Kg/m^3 and at an atmosphereic pressure of 1.013 x 10^5 nt/m^2.

12. In the following diagram the Doppler effect, source, observer, and medium are all in motion along the positive x-axis.



$$f = f_o \frac{V \; V_m - V_o}{V \; V_m - V_s}$$

A source of sound emitting a note of frequency 400 vps is moving toward the west with a velocity of 25 ft/sec. Directly to the east of the observer who is moving to the east with a velocity of 40 ft/sec. there is a wind blowing from the east 55 ft/sec., and the velocity of sound in still air is 1100 ft/sec. Find the frequency of the note received by the observer.

REFERENCES - MATERIALS

Recommended Text: University Physics, Sears, Francis W. and Zemansky, Mark; Addison Wesly Publishing Company

Reference Books for Advanced Placement Physics Courses
Addison - Wesly Physics Series
Cambridge 42, Massachusetts

1. Introduction to Concepts and Theories in Physical Science, Holton
2. Fundamentals of Electrons, Mitchell
3. Discovering Physics, Knauss
4. College Physics, Sears and Zemansky

Principles of Physics Theory, Addison-Wesly, Reading, Mass.

5. Theoretical Physics, Mechanics, Constant
6. Introduction to Electric Theory, Fowler
7. Introduction to Acoustics, Randall
8. Optics, Rossi

9. Optics, Sears

10. Mechanics, Symon

11. Mechanics, Heat, and Sound, Sears

12. Electricity and Magnetism, Sears

13. Thermodynamics, the Kinetic Theory of Gases, and Statistical Mechanics, Sears

14. Quantum Theory of Angular Momentum, Feenburg and Pake

15. Classical Mechanics, Goldstein

16. The Theory of Photons and Electrons, Jauch and Rohrlich

17. The Classical Theory of Fields, Landau and Lifshitz

18. Classical Electricity and Magnetism, Panafsky and Phillips

19. Nuclear Theory, Phillips and Sachs

20. Introduction to Pile Theory, Goodman

21. Application of Nuclear Energy, Goodman

22. Pile Neutron Research, Hughes

23. Nuclear Physics, Kaplan

24. Sourcebook on Atomic Energy, Glasstone, D Van Nostrand Co., Inc., New York, N. Y.

25. HandBook of Chemistry and Physics, Chemical Rubber Publishing Co., Cleveland, Ohio

26. Nature and Growth of the Physical Sciences, Cohen, John Wiley and Sons, Inc.

27. Mathematics for the Millions, Hogben, W. W. Norton and Co., New York, N. Y.

28. Introduction to Concepts and Theories in Physical Science, Holton, Addison-Wesly Publishing Co., Inc.

29. Mathematics in Western Culture, Kline, Oxford University Press

AUDIO-VISUAL AIDS - Motion Pictures

Unit I. Mechanics

Air in Action	Liquid Air
Atmospheric Pressure	Scientific Method
Diesel Engine	Weighing with the Analytical Balance
Diesel Story	
Harnessing Liquids	

Unit II. Heat

Heat and Its Control	Heat and Pressure
Nature of Heat	Thermodynamics

Unit III. Sound

Co-axial Cable	Looking at Sound
How Motion Pictures Talk	Mr. Bell
	Speeding Speech

Unit IV. Electricity and Magnetism

Electrons	Electrodynamics
Electrons at Work	Primary Cell
Electrostatics	

Unit V. Optics

Light and Shadow	Nature of Light
Light Control through Polarization	Speed of Light

Unit VI. Atomic Physics

Atomic Energy	Carbon Fourteen
Atomic Power	Matter and Energy
Bottle of Magic	Our Friend the Atom

PROFESSIONAL AIDS

1. College Entrance Examination Board, Advanced Placement Program, 425 West 117 St., New York 27, N. Y.

2. Analytical Experimental Physics, Ference, Lemon, Stephenson; University of Chicago Press, Chicago, Illinois

3. "Scientific American", 2 West 45th Street, New York 36, N. Y.

4. "Science", American Association for Advancement of Science, 1515 Massachusetts Avenue, Washington 5, D. C.

5. "Scientific Monthly", American Association for Advancement of Science, 1515 Massachusetts Avenue, Washington 5, D. C.

6. "Physics Today", 335 East 45th Street, New York 17, N. Y.